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Patterson,
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NON-POINT SOURCE POLLUTION AND PLANNING FOR WATER QUALITY IMPROVEMENTS IN WESTERN STANISLAUS COUNTY

NON-POINT SOURCE POLLUTION AND PLANNING FOR WATER QUALITY IMPROVEMENTS IN WESTERN STANISLAUS COUNTY

Prepared for:

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By:
Robert Bailey, Soil Conservationist
John McClung, Engineer
David Faulkner, Agricultural Economist

U.S. Department of Agriculture,
Soil Conservation Service
Patterson Field Office
218 N. El Circulo
Patterson, CA 95363

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES AND MAPS

CHAPTER I

EXECUTIVE SUMMARY

Over the last ten years the irrigated agriculture area of the West-side of Stanislaus County has been the principal subject of numerous reports, planning efforts and one successful pilot program. These works were conducted under the auspices of the U.S.D.A., the State of California Regional Water Quality Control Board and West-side Resource Conservation Districts (now consolidated into one RCD). These efforts were undertaken based predominantly on a concern for the water quality effects of agricultural non-point source pollution (NPSP).

The West-side has been recognized as a consistent NPSP source area due to the combined effects of: (a) the area's physical geography and location immediately adjacent to the San Joaquin river; (b) it's extensively altered system of surface and subsurface hydrology; (c) it's soils that are derived from coastal-range parent material which yields finer textured and more fertile and erosive soils than are generally found on the east side; and consequently (d) more intensive land use patterns adjacent to the river relative to other areas in the basin (115,000 acres of intensively managed and relatively high-valued irrigated agriculture lie between the San Joaquin River and Interstate highway 5). The area is also considered important due to the state-wide importance of the main impaired water body that the San Joaquin River affects - the Sacramento/San Joaquin Delta and water transfers for high-valued uses in the south of the state.

The West-side irrigated agricultural lands special focus of this study was chosen based on: (1) the earlier studies that identified the area as the single most important and consistent contributor of NPSP pollutants within the San Joaquin River Basin area (upstream of the Delta) and (2) previous water quality work experience in the area gained through the implementation of a joint RCD/SCS/SWQCB pilot project to install selected Best Management Practices (BMPs).

The pilot project also monitored and evaluated specific practices for their NPSP abatement effectiveness. The pilot project experience demonstrated that well implemented BMPs can be very effective in reducing NPSP loadings from irrigated lands ranging from 20% - 90% efficiency. A more detailed treatment of the Spanish Grant and Crow Creek pilot project's results are summarized in the final report submitted to the SWQCB by the RCD and Patterson field office of the SCS, dated December 1987.

Sampling of West-side drains conducted for this study indicates that variation in flow rates, Total Suspended Solids (TSS) and sediment content is very marked from one drain to the next and during the year. Greatest concentration of TSS occurs during the peak period of the irrigation season (July-August) with recorded samples as high as 7800 mg/l from one drain and estimated sediment loads as large as 140 tons/24 hrs from another. However, three drains were found to produce 51 percent of the total estimated flow and 50 percent of the 24 hour estimated sediment yield.

- during irrigation season or all year?

<u>In summary, all work to date indicates that the area is a significant contributor of NPSP pollutants and that Best Management Practices, either singularly or in combination, can be very effective for reducing NPSP loadings being delivered from the area into the San Joaquin River.</u>

The work performed in the area thus far, for understandable reasons, has sometimes been focused on special concerns and localized areas of the west-side without fully linking on-farm resource management with the broader issues related to offsite damages, hydrological boundaries and all sources of NPSP on the West-side, e.g., groundwater, rangeland, unmanaged native vegetation areas, highways where significant quantities of chemical herbicides are often used, etc. Therefore, it is recommended that:

An interdisciplinary team of specialists conduct a comprehensive rapid reconnaissance of the entire West-side to (a) more clearly link the water quality problems associated with NPSP from the west-side with the key water quality impairing pollutants and their sources; (b) identify important damage categories and estimate dollar values resulting from the impairment of beneficial uses for those that are economically quantifiable; (c) estimate treatment costs; and (d) recommend implementation alternatives.

CHAPTER II

INTRODUCTION

The Non-Point Source Pollution Problem

The conservation of our soil and water resources has been recognized as a National issue of economic and political importance since the 1930's when the federal government began directing and financially supporting conservation programs. Since then our national experience in this area has not diminished concern nor efforts to deal with soil erosion and related water pollution problems. In fact, our experience of the last 50 years has led to a broadening of scientific as well as public inquiry into the complex problems and questions raised by soil erosion and water quality degradation as the problems themselves have become more pervasive. Concurrently, there has been a sharpening of debate on these topics. Implicit in conservation efforts is the general goal of allocating resources in an attempt to maximize services from the environment while minimizing waste and pollution.

Environmental management represents a great challenge to our society. In spite of increased awareness and efforts to lessen erosion and minimize the harmful effects of water movement on and through agricultural lands, soil erosion and water quality degradation probably increased during the 1970's. Water-caused soil erosion results in productivity losses, increased production costs and when combined with animal waste and agricultural chemical run-off, off-site damages known as non-point source pollution (NPSP). Non-point source pollution may be defined as damage to water quality in bodies of water as a result of the diffuse and often non-specific loading of organic and inorganic materials that many of man's activities and natural processes produce (see Appendix D). Nature's contribution to non-point source pollution can be the most important component of sediment load. For example, it is estimated that irrigated cropland will yield only 8.5% of the total annual Central Valley sediment production. Steeper alluvial fans and foothills produce the majority of the sediment load [13]. However, sediment loads from agricultural lands are often more harmful to receiving water bodies due to associated loadings of agricultural chemicals and the seasonal nature of irrigated agriculture induced sedimentation.

Regardless of the source, eroded sediments can fill in streams, lakes and reservoirs. Sedimentation can lead to navigation, recreation, fish spawning and other wildlife problems as well as water treatment, energy production and flood control problems. Fertilizers, pesticides and animal wastes also contribute to water treatment problems, but in addition, they strain and often disrupt the natural assimilative capacity of the environment to filter-out sediments and break-down toxic substances. Complex water ecology problems and wildlife habitat problems can then result.

Nutrient loading in waterways can cause "algae blooms" which create an imbalance in the chemical and biological relations among the plant and animal life present. The excessive presence of nutrients in water causes accelerated eutrophication which is the natural aging process of water bodies that can lead to discoloration, repulsive odors and loss of beneficial uses.

Bacteria from animal wastes create human health problems when municipal water supplies, recreation areas, and groundwater wells become contaminated. Ground water wells are the primary sources of water for many Californians living in rural areas.

When pollutant loading is within environmental limitations, the soil acts as an excellent treatment facility, transforming animal wastes and fertilizers into harmless organic forms. However, the ability of the soil to perform this service is limited and dependent upon climatic conditions, soil type, topography and the type of land usage to which the land is subjected.

The filtering capability of soil is excellent with most organic substances, but this is not true with many agricultural chemicals and byproducts of land use activities such as waste oil from farm machinery. Due to their chemical nature, some of these substances are able to persist or build up in the environment and cause damages with far ranging implications.

The Federal Water Pollution Control Act of 1972 established the national goal of "fishable and swimmable waters" by 1983. Recognizing that point source control alone would not achieve this goal, Section 208 of the act required the development of areawide planning programs to involve Federal, State, regional and local governments in a coordinated effort to address non-point source pollution problems as well.

The thrust of the 1972 legislation and 1977 amendments in dealing with NPSP have become known as "best management practices" (BMPs). Best management practices for agriculture include managerial and cultural practices as well as structural facilities. Applied to crop and livestock enterprises, they are believed to be the most effective means currently available to prevent and/or reduce NPSP to levels compatible with water quality goals. They are applicable to many farm activities that generate NPSP and are designed to be adapted to the site specific characteristics of any individual farm.

Production incentives and other inducements to farm growth have been disincentives to conserve soil resources and reduce non-point source pollution. The costs of erosion control and NPSP abatement often entail large, short-term expenditures and smaller long-term maintenance expenditures. Farmers consider these expenditures in terms of the production opportunities foregone and the possible income levels that would be attainable without BMP implementation. BMPs on agricultural lands can significantly reduce soil erosion and NPSP, but additional information is needed regarding potential effects of alternative public policies on farm level financial conditions and the achievement of water quality goals.

Structural and cultural practices will be adopted by farmers only when the benefits of adoption exceed the costs. Given that the short-term costs of erosion are often less than the costs to control erosion, a rationale exists for society at large to alter farmer's decisions to erode at some level or not erode by providing them cost-share subsidies, income tax breaks, regulation or through other policy mechanisms.

Study Objectives

The Patterson Field Office of the Soil Conservation Service was contracted by the California Water Resources Control Board to specifically study non-point source pollution from suspended sediment in irrigation return flow on the "West-side" of Stanislaus County. The objectives of the study were to:

Completed

1. Identify the major agricultural drains on the West -side.

SWRCB 85-87 extreme variability so monitored on wkly basis in 88 irrigation - ID'd major flow & sediment sites (~3 or 4 drains

2. Estimate the magnitude and frequency of excess irrigation water discharge into the drains.

need further assessment for specific crops ← right now have range

need more flow info ie. meter

3. Identify and estimate the impacts of farming operations on sediment loads.

Listed what was known in Spanish Grant but don't have latiest ie. furrow torpedos & surge

4. Identify "Best Management Practices" that can reduce runoff and suspended sediment in irrigation tailwater.

lack of time - can say by farm but not by water shed

5. Develop costs for implementing different levels of farm drainage flow reduction.

6. Assess methods to increase grower awareness of the need for conservation practices.

Newsletter
Eldon has new group
irrigation & water quality workshops
gypsum block program;
W. Stanislaus only Valley Office receptive to finding out quality impaired water bodies

The Study Area

The study area is located in western Stanislaus County and encompasses approximately 114,000 acres (178 square miles) of irrigated farm land. The area is bounded on the north by the San Joaquin County line, on the south by the Merced County line, on the West by the Delta Mendota Canal and on the East by the San Joaquin River (see Location Map). Within this area the Central Valley Region Water Quality Control Board has identified 26 surface drains discharging sediment and other pollutants into the San Joaquin River (Unpublished Central Valley Region Water Quality Control Board Field Notes). The West-side Surface Drainage Map shows sample locations and drainage area boundaries. These drains represent return flows from approximately 78,000 acres (122 square miles) with individual areas ranging in size from 230 acres (0.37 square miles) to 15,000 acres (23.4 square miles). See Table 1 for a summary of the drainage areas.

TABLE 1 STUDY AREA SURFACE DRAINS, LANDUSE, SLOPES, FLOW, AND SEDIMENT YIELD SUMMARY (SOURCE 1988 PATTERSON FIELD OFFICE DATA)

SITE DESCRIPTION	STATION #	DRAINAGE AREA ACRES	AVERAGE SLOPE %	ROW CROP ACRES	ORCHARD CROP ACRES	FIELD CROP ACRES	OTHER USE ACRES	AVERAGE(1) FLOW CFS	AVERAGE(1) SEDIMENT TONS — per day?
HILLS FERRY DRAIN	014	4500	0.2	1880	550	1400	670	(2)	(2)
AZVEDO ROAD DRAIN Azevedo	015	2800	0.4	1400	30	1300	70	6.9	1.0
UNNAMED TAILWATER DRAIN	016	740	0.3	700	0	0	40	1.7	0.8
FREITAS ROAD DRAIN	017	1900	0.3	1700	150	0	50	4.9	2.8
ORESTIMA CREEK	019	6400	0.0	4100	1600	200	500	39.1	48.9
SPANISH GRANT COMBINED DRAIN	021	14740	0.5	10400	1800	1700	840	(2)	(2)
RAMONA LAKE MAIN DRAIN	022	4200	0.4	3400	150	600	50	7.3	2.1
PATTERSON WATER DISTRICT DRAIN	023	230	0.2	115	110	0	5	(2)	(2)
OLIVE AVENUE DRAIN	024	4710	0.7	1660	2000	900	150	(2)	(2)
EUCALYPTUS AVENUE DRAIN	025	390	0.3	250	120	0	20	2.1	6.4
DEL PUERTO CREEK	026	6400	0.6	3240	2550	360	250	10.7	6.4
RICHIE SLOUGH DRAIN	027	1200	0.5	780	310	30	80	5.8	14.1
DEL MAR DRAIN	028	1100	0.6	990	60	0	50	6.0	26.9
WESTLEY WASTEWAY	029	3400	0.7	1740	1400	0	260	14.5	27.1
GRAYSON RD. DRAIN	030	2700	0.7	1900	600	50	150	2.7	10.8
MINNIE RD. DRAIN	031	1200	0.6	900	250	0	50	(2)	(2)
KELNER RANCH DRAIN	034	540	1.0	370	110	0	60	(2)	(2)
HAGERMAN DRAIN	036	3100	0.5	2750	200	0	150	39.4	49.2
INGRAM CREEK	040	6800	0.8	5120	1060	150	470	11.9	46.0
HOSPITAL CREEK	042	3260	0.5	2000	900	180	180	9.6	22.0
CENTER RD. DRAIN	043	1100	0.3	1080	0	0	20	3.4	3.6
EL SOLYO WATER DISTRICT MAIN DRA	044	680	0.5	500	0	170	10	2.3	2.4
MAGNOLIA AVE. DRAIN	050	530	0.5	350	160	0	20	(2)	(2)
BLEWETT DRAIN	051	3220	0.9	800	315	1780	325	9.4	16.2
GONSALVES AREA DRAIN	052	2200	0.3	2000	140	0	60	(2)	(2)
BERNARD DRAIN	053	340	0.4	200	20	100	20	(2)	(2)
TOTAL		78380		50325	14585	8920	4550		
SQ. MI.		122							

NOTE 1: ASSUMED 24 HOUR CONSTANT FLOWRATE

NOTE 2: NOT SAMPLED WEEKLY IN 1988

CHAPTER III

RESOURCE INVENTORY

Basic Data

In order to help determine the potential sediment load from each drain, a database was developed which contains information on the following drains/drainage area characteristics:

1. Soils.
2. Land use (i.e. cropping).
3. Topography.
4. Water use.

Additional information included in the database are drainage boundaries and conservation district, drainage district, and irrigation district boundaries.

Soils

The relationship between soil classification and erodibility is a function of those soil properties that affect infiltration and movement of water through the soil, water storage capacity, and those that affect dispersion, cohesiveness, abrasiveness, and mobility of soil particles by runoff. Some of the most important of these properties are texture (percent sand, silt, or clay), organic matter content, particle and aggregate size, stability of structure, and permeability.

The SCS has quantitatively evaluated these factors to develop a soil erodibility indicator or "k" factor. This k factor is a measure of the susceptibility of the soil to detachment and transport and may range in value from 0.02 to 0.64 with 0.64 being the most erosive.

The 1968 University of California, Davis soil survey of Western Stanislaus County identified 52 distinct soil groups within the study area. For these 52 soil groups in the West-side study area the k factor ranges from 0.10 to 0.43. Table 2 shows the major soils in the study area grouped by erodibility class and average slope (See Soil Erodibility Map for spatial distribution of k factors in the study area).

TABLE 2 WESTERN STANISLAUS COUNTY SOILS

Map Symbol	Soil Name	Surface Texture	Slope Ranges	K Value	Acres	% of Total Soils
AN2	Anderson	Very gravelly clay loam	0 - 3	0.1	109	0.09
CT2	Cortina	Very gravelly loam	0 - 2	0.15	205	0.18
CT3	Cortina	Very gravelly sandy loam	0 - 2	0.15	109	0.09
SD4	Salado	Gravelly sandy loam	0 - 2	0.2	310	0.27
VE6	Vernalis	Gravelly clay loam	3 - 8	0.2	514	0.45
VE7	Vernalis	Gravelly loam	0 - 1	0.2	1048	0.91
VE8	Vernalis	Gravellv loam gravelly substratum	0 - 1	0.2	99	0.08
ZA5	Zacharias	Gravelly clay loam	0 - 1	0.2	137	0.12
ZA6	Zacharias	Gravelly loam	0 - 1	0.2	475	0.41
ZA7	Zacharias	Gravelly loam	3 - 10	0.2	154	0.13
ZA12	Zacharias Arbuckle	Gravelly substratum complex	0 - 1	0.2	1538	1.34
CC2	Capay	Clay	0 - 1	0.24	2711	2.36
CC3	Capay	Clay	0 - 1	0.24	145	0.13
MY8	Myers	Gravelly clay	0 - 2	0.24	83	0.07
AR2	Arbuckle	Clay loam	0 - 2	0.28	482	0.42
MY2	Myers	Clay	0 - 2	0.28	10547	9.18
MY3	Myers	Clay loamy substratum	0 - 2	0.28	2429	2.11
MY4	Myers	Clay	0 - 2	0.28	238	0.21
MY5	Myers	Clay	0 - 2	0.28	1734	1.51
MY6	Myers	Clay loam	0 - 2	0.28	3944	3.43
MY7	Myers	Clay loam	0 - 2	0.28	226	0.20
MY9	Myers-Stomar	Complex	0 - 4	0.28	149	0.13
VE2	Vernalis	Clay	0 - 1	0.28	83	0.07
CA2	Camarillo	Clay loam	0 - 1	0.32	1900	1.65
CA3	Camarillo	Clay loam Hard substratum	0 - 1	0.32	42	0.04
CA4	Camarillo	Loam	0 - 1	0.32	1557	1.35
CC4	Capay	Clay	0 - 1	0.32	143	0.12

Map Symbol	Soil Name	Surface Texture	Slope Ranges	K Value	Acres	% of Total Soil
CO2	Columbia	Fine sandy loam	0 - 1	0.32	764	0.66
CO3	Columbia	Fine sandy loam sandy substratum	0 - 1	0.32	93	0.08
CO4	Columbia	Fine sandy loam		0.32	754	0.66
CO5	Columbia	Fine sandy loam	0 - 1	0.32	190	0.16
CO6	Columbia	Fine sandy loam	0 - 1	0.32	500	0.44
CO7	Columbia	Soils channeled		0.32	1364	1.19
CO8	Columbia	Loamy fine sand	0 - 1	0.32	168	0.15
CO9	Columbia	Silt loam	0 - 1	0.32	373	0.32
ME3	Merced	Clay	0 - 1	0.32	1094	0.95
ME4	Merced	Clay loam	0 - 1	0.32	75	0.06
PO2	Positas	Clay loam	0 - 2	0.32	966	0.84
SA2	Sacramento	Silty clay	0 - 1	0.32	1110	0.97
SA3	Sacramento	Silty clay	0 - 1	0.32	44	0.04
SA4	Sacramento	Silty clay loam	0 - 1	0.32	261	0.23
SD2	Salado	Fine sandy loam	0 - 2	0.32	4076	3.55
SD3	Salado	Fine sandy loam sandy substratum	0 - 2	0.32	166	0.14
SD5	Salado	Loam	0 - 2	0.32	4065	3.54
SD6	Salado	Silt loam	0 - 2	0.32	140	0.12
VE3	Vernalis	Clay loam	0 - 1	0.32	18921	16.47
VE4	Vernalis	Clay loam	0 - 1	0.32	912	0.79
VE5	Vernalis	Clay loam silty substratum	0 - 1	0.32	1645	1.43
AR3	Arbuckle	Loam	0 - 2	0.37	329	0.29
DN2	Dinuba	Fine sandy loam	0 - 1	0.37	276	0.24
OR4	Orestimba	Clay loam	0 - 1	0.37	2353	2.05
OR5	Orestimba	Clay loam, wet	0 - 1	0.37	54	0.05
PO3	Positas	Loam	0 - 2	0.37	1421	1.24
ST2	Stomar	Clay loam	0 - 1	0.37	4760	4.14
ST3	Stomar	Clay loam	0 - 1	0.37	920	0.80
ST4	Stomar	Loam	0 - 1	0.37	721	0.63
TE2	Temple	Clay loam	0 - 1	0.37	964	0.84
TE3	Temple	Clay loam	0 - 1	0.37	918	0.80
TE4	Temple	Clay loam channeled		0.37	95	0.08
VE9	Vernalis	Loam	0 - 1	0.37	18454	16.10
VE10	Vernalis	Loam, water table	0 - 1	0.37	143	0.12

Map Symbol	Soil Name	Surface Texture	Slope Ranges	K Value	Acres	% of Total Soils
VE12	Vernalis	Loam, silty substratum	0 - 1	0.37	149	0.13
VE13	Vernalis	Loam, clay substratum	0 - 1	0.37	107	0.09
VE14	Vernalis	Loam, hard substratum	0 - 1	0.37	48	0.04
VE15	Vernalis	Silt loam	0 - 1	0.37	2034	1.77
ZA2	Zacharias	Silt Loam	0 - 1	0.37	5114	4.45
ZA3	Zacharias	Clay loam Gravelly substratum	0 - 1	0.37	131	0.11
ZA4	Zacharias	Clay loam	0 - 1	0.37	214	0.19
ZA8	Zacharias	Loam	0 - 1	0.37	1284	1.12
ZA9	Zacharias	Loam, gravelly substratum	0 - 1	0.37	541	0.47
ZA10	Zacharias	Loam, clay substratum	0 - 1	0.37	42	0.04
ZA13	Zacharias Positas	Gravelly substratum complex	0 - 1	0.37	511	0.44
ES2	El Solyo	Silty clay loam	0 - 1	0.43	2867	2.49
ES3	El Solyo	Silty clay loam silty substratum	0 - 1	0.43	178	0.15
TE5	Temple	Loam	0 - 1	0.43	302	0.26
TE6	Temple	Loam, Water table	0 - 1	0.43	154	0.13
TE7	Temple	Loam	0 - 1	0.43	159	0.14

FIGURE 1 WEST–SIDE STUDY AREA LAND USE

USDA–SCS 1982 AERIAL PHOTOS UPDATED

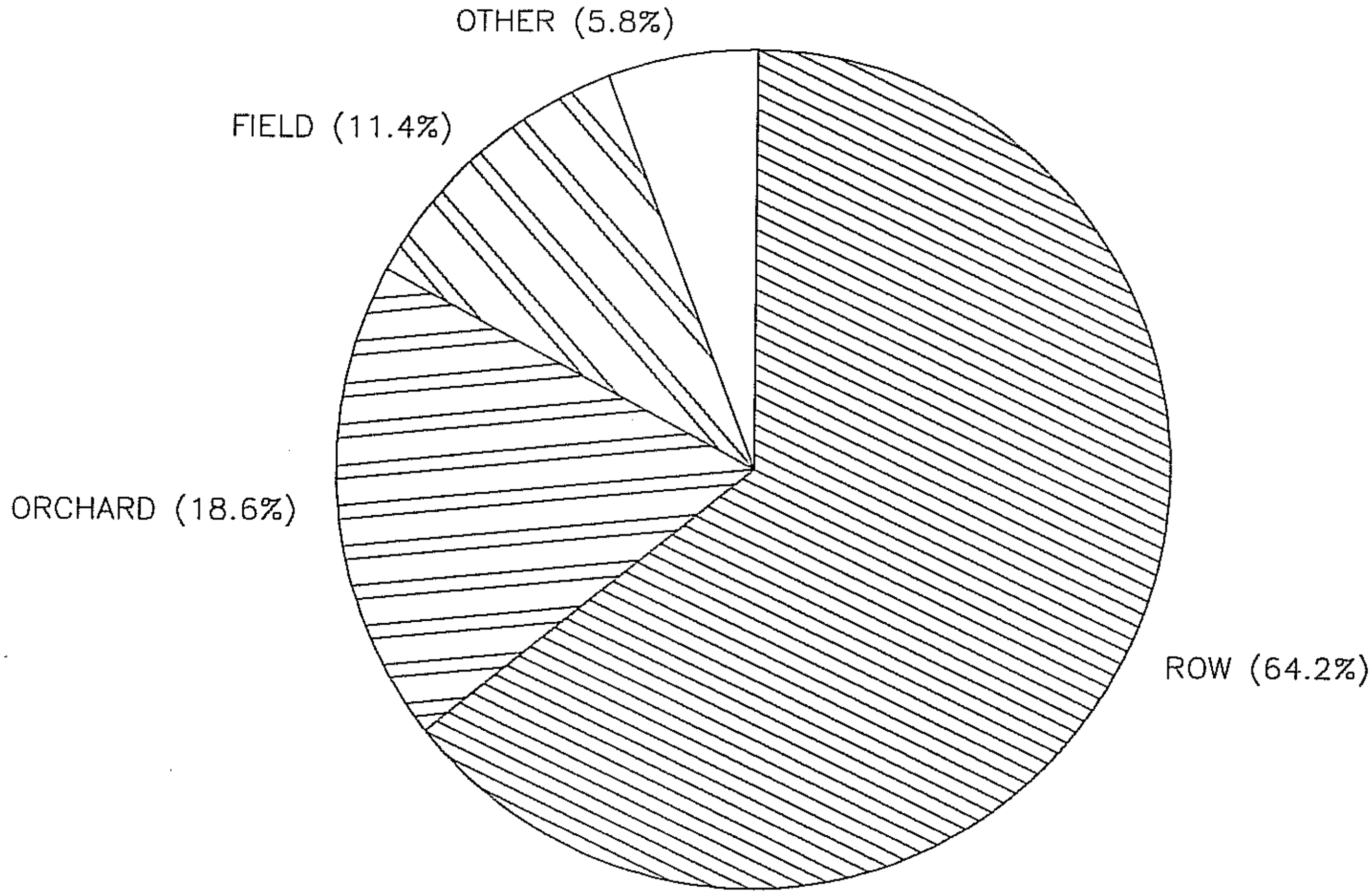


TABLE 3 AVERAGE ANNUAL TAILWATER AND SEDIMENT LOAD FOR CROPS IN SPANISH GRANT

CROP	AVERAGE YEARLY WATER USAGE	AVERAGE TAILWATER	AVERAGE SOIL LOSSES FROM FIELD
	ac-ft/ac	ac-ft/ac	tons/ac
ALFALFA	3.7	0.8	0.2
ALMONDS	2.8	0.6	0.2
BEANS	2.9	0.7	1.6
CANNING TOMATOES	3.9	1.1	4.0
GREEN TOMATOES	3.9	1.1	1.2
WALNUTS	3.6	0.8	1.2

TABLE 4 AVERAGE ANNUAL SOIL LOSSES FROM FURROW IRRIGATED CROPLAND IN THE BOISE AND MAGIC VALLEY AREAS

	slope		
CROP	0 TO 1%	1 TO 2%	OVER 2%
	(tons per acre annual loss)		
ALFALFA	0.0	0.0	3.0
WHEAT	0.5	1.0	4.0
PEAS	1.5	4.0	8.0
BEANS	2.5	7.0	18.0
CORN	2.5	8.0	20.0
BEETS	4.0	12.0	30.0

basin slope for the outfalls mapped are, with one exception, less than one percent. This reflects the extensive land leveling on the West-side. Thus, on the average, study area basin slopes are less than those slopes believed to generate a rate of soil loss detrimental to agricultural production. However, individual field slopes may exceed this critical slope. There has been little research on the effect of increasing drainage density and the resulting basin efficiency in sediment delivery rates from irrigated lands.

Water Use

The relationship between cropping (land use) and erosion is an important factor in targeting those areas that are sources of high potential pollution through sediment loading. Each crop has distinct water use requirements. Therefore, crop requirements along with the method of irrigation (in terms of overall irrigation efficiency) and plant density result in particular levels of erosion, if other factors are constant. For example, while alfalfa requires large quantities of water, the crop itself acts as a filter media reducing the sediment load in drainage water. The effect of alfalfa in reducing erosion has been shown in work by Everts and Carter [4]. Additionally, University of California, Davis research has shown that "long season, deep rooted crops tend to be irrigated more efficiently (create less drainage) than shallow rooted, salt sensitive, short season crops" [11]. Long season deep rooted crops include alfalfa and sugarbeets, while most vegetable crops are short season shallow rooted crops. Usually, vegetable crops require more frequent irrigations and also some pre-irrigation, thus reducing overall irrigation efficiency and resulting in excessive runoff.

Other important water use related factors affecting sediment load in irrigation runoff are sediment load in source water, water pricing, and irrigation water management.

The relationship between the quality of the water applied to a field and the quality of the resultant tailwater may be measured in terms of dissolved salts and suspended sediments (TSS). Electrical Conductivity (EC) readings from the Spanish Grant Pilot Study show very little change in quality between the applied water and surface water samples collected at end of field sumps [6]. This is similar to test results in other areas on the West-side and in the pre-irrigation water sampling for this study. On the other hand, there are significant differences between Total Suspended Sediment (TSS) concentrations in source water and those measured in agricultural drains throughout the West-side. Irrigation drainwaters from subsurface drains tend to have higher EC's than supply waters but be lower in (TSS), while surface drainwaters may have TSS differences several orders of magnitude depending on time of year and flow levels in the drains. Base level TSS may become a more significant problem when drain water is reused by downstream growers.

Water pricing can have a direct impact on water use in an area. As the price of water increases there tends to be more efficient use of water and less waste. This directly impacts the total amount of runoff from fields and usually results in less total sediment as measured in total tons from a basin. Table 5 shows cost per acre-foot of three typical West-side water sources. Also included is base level TSS averages from a three year sampling period. It should be noted, that there are other significant West-side water sources such as groundwater, the Delta-Mendota Canal, and drain water reuse.

Due to the relatively low cost of water on the West-side, water pricing is not a significant factor in determining farming practices and operations. See Irrigation District Map for West-side Water Districts currently in operation.

TABLE 5 West-side Irrigation District Cost/Ac-ft & TSS Levels

DISTRICT	WATER COST/ Ac-ft	AVG TSS/ mg/l	DATES OF OPERATION
*CCID	$ 5.50	NR	JAN. 15- NOV. 15
PATTERSON WATER DISTRICT	$16.50	61	MARCH 1 - SEPT.30
WEST-SIDE IRRIGATION DISTRICT	$18.00	71	JAN. 1 - DEC. 31

*Central California Irrigation District

NOTE: These delivery dates may be adjusted during dry years or based on customer need. These dates do not cover use of individual wells and other private sources.

The third and most important water use factor is the growers' expertise in implementing Irrigation Water Management (IWM). The definition and purpose of IWM are as follows:

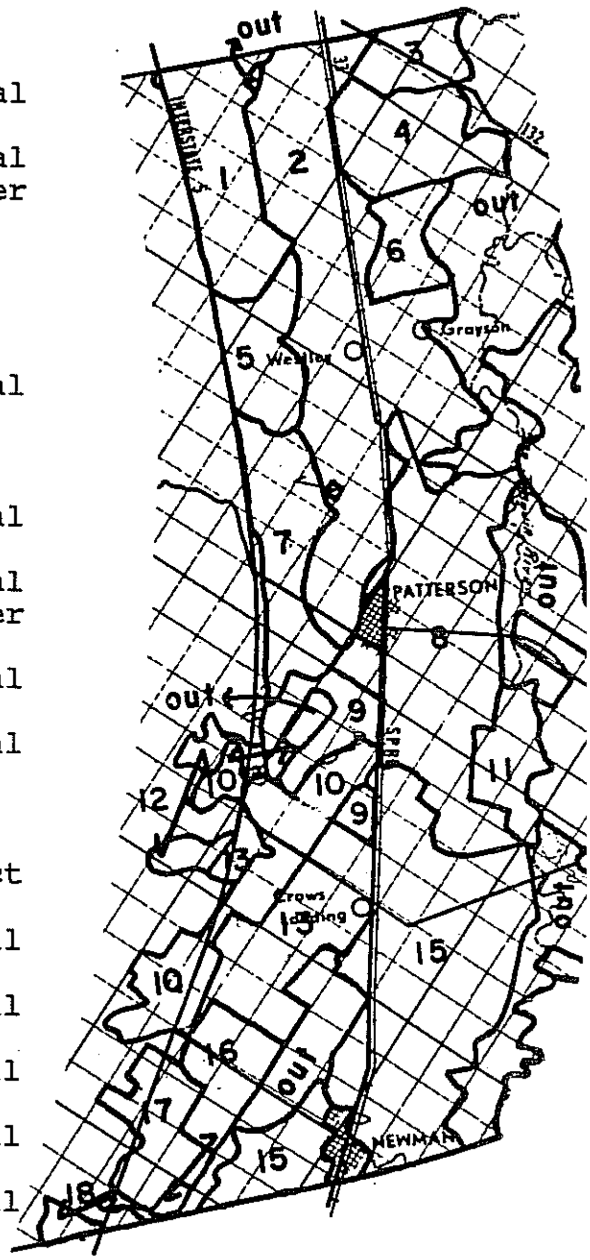
"the act of controlling or regulating irrigation water applications in a way that will satisfy the water requirements of the crop without the waste of either water or soil. It involves applying water in accordance with crop needs, in amounts that can be retained in the soil for crop use and at rates that are consistent with the intake characteristics of the soil and the erosion hazard of the site.

The purpose of applying IWM is multifaceted. It provides for the effective use of an available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop responses, to minimize soil

WEST STANISLAUS IRRIGATION DISTRICT MAP

Legend:

	IRRIGATION DISTRICT	WATER SOURCE
*	1. Hospital	Delta Mendota Canal
	2. West Stanislaus	Delta Mendota Canal & San Joaquin River
	3. Blewitt	San Joaquin River
	4. El Solyo	San Joaquin River
*	5. Kern Canyon	Delta Mendota Canal
	6. White Lake	San Joaquin River
*	7. Del Puerto	Delta Mendota Canal
	8. Patterson	Delta Mendota Canal & San Joaquin River
*	9. Salado	Delta Mendota Canal
*	10. Sunflower	Delta Mendota Canal
	11. Twin Oaks	San Joaquin River
*	12. Oak Flat	California Aqueduct
*	13. Orestimba	Delta Mendota Canal
	15. Central CA	Delta Mendota Canal
*	16. Foothill	Delta Mendota Canal
*	17. Davis	Delta Mendota Canal
*	18. Mustang	Delta Mendota Canal



* Administered by Harrison Services, Westley, CA.

erosion and loss of plant nutrients, to control undesirable water loss, and to protect water quality"[9].

While most agree that management of water is an important influence on total water use, it may well be the hardest factor to control since it can be affected by physical constraints, water availability, economic decisions, social conditions, and availability of educational programs.

Typical crop water use for Western Stanislaus County are shown in Table 6. These data are based on consumptive use for the geographic area generated by the Blaney Criddle Formula using climatological information from the Newman station located near the southern boundary of the study area. Any management program tries to balance this use requirement with other constraints to achieve the most efficient use of available water.

TABLE 6 TYPICAL PLANT WATER USE DATA
STANISLAUS COUNTY - NEWMAN STATION

CROP	NET IRRIGATION APPLICATION AC-IN/AC IRRIGATION	PEAK CONSUMPTIVE USE AC-IN/DAY/AC	NET IRRIGATION REQUIREMENT AC-IN/AC/YR
ALFALFA	5	.31	35
ALMONDS	5	.18	15
APPLES	4	.25	24
APPLES W/COVER	4	.32	40
BRUSSEL SPROUTS	5	.14	10
CITRUS	5	.20	25
CORN (GRAIN)	5	.30	25
CORN (SILAGE)	5	.28	20
CORN (SWEET)	5	.31	25
DECIDUOUS ORCH.	6	.32	42
DRY BEANS	5	.32	20
GRAIN	5	.17	5
GRAIN SORGHUM	5	.31	25
GREEN BEANS	5	.32	15
MELONS	5	.25	15
ORCHARDS W/O COV	5	.25	25
PASTURE	5	.26	35
PEAS	5	.14	5
SUGAR BEETS	5	.34	35
TOMATOES	5	.29	25
VEGETABLES	5	.18	10

CHAPTER IV

FARMING METHODS AND PRACTICES

Runoff from irrigated land occurs when the amount and rate of water applied exceeds either a given soil's intake capacity or the amount required to replenish the soil profile to holding capacity. Systems for applying irrigation water can be grouped into two broad categories: gravity flow (surface systems) and pressurized flow (drip, micro, and sprinklers).

Gravity systems apply water by flow across the field and, even with a well designed system, precise control of the water is impossible because of irregularity of slope and soil conditions. Gravity systems include furrow, gated pipe and level basins.

Pressurized systems, if properly designed and maintained, allow control of application rates to more closely match the intake rate of the soil to minimize or eliminate runoff.

The type of irrigation system used depends on several factors such as soil type and crop, water quality and quantity, and economics. Pressurized systems particularly lend themselves to use in orchards. However, surface systems are also quite common in orchards. The majority of row cropland on the West-side is irrigated by some form of furrow system using either gated pipe or siphons.

Mechanics of Furrow Irrigation

In general, return flow in agriculture is defined as either spillage of excess water from supply sources (canals and wells), excess flow from farm head ditches , or irrigation runoff. In order to understand the impact of furrow irrigation on sediment delivery, it is necessary to examine the critical factors affecting volume of tailwater and sediment load from an individual field. SCS experience has identified the following four factors as critical for predicting irrigation-induced erosion on individual fields:

1. Stream size: Since the furrow acts as both an infiltration area and transport channel, the stream size must be large enough to satisfy infiltration needs and to reach the end of the field within reasonable time limits. As the volume of water released into a furrow increases the velocity of flow increases and results in more energy in the system. To balance

this increased energy level more soil particles are transported until equilibrium is restored.

2. Slope: As is the case with stream size, slope has a direct impact on the transport energy of the furrow stream. As the field slope increases, so does the ability of the stream to transport sediment. This continues until an energy balance is reached.

3. Soil texture and surface condition: Soil texture is a complex function of particle size and the chemical and physical structure of the soil mass. The surface condition is a highly variable factor affected by soil moisture, vegetative cover (weeds and crop cover) time of the growing season, and cultivation practices.

4. Cropping: The impact of cropping on erosion potential is due to such factors as plant density, foliage in the furrows, water requirements, and cultural practices.

Each of these factors are interrelated and their interaction on the field surface results in a distinct pattern of scour- deposition-scour that makes the prediction of sediment yield from irrigated land extremely complex. Figure 2 shows how these complex factors were combined graphically and used to estimate sediment volume based on USDA data for the Yakima Valley in Washington. However, even with extensive experimental data the prediction of sediment volume from irrigated land is extremely difficult due to the complex interaction on the field between slope, soil, crop, management, and water. It is important to note that predicting sediment quantity from an individual field is not the same as predicting sediment yield at the drainage outlet. Many additional factors can substantially alter both the quantity and the characteristics of the sediment reaching receiving waters.

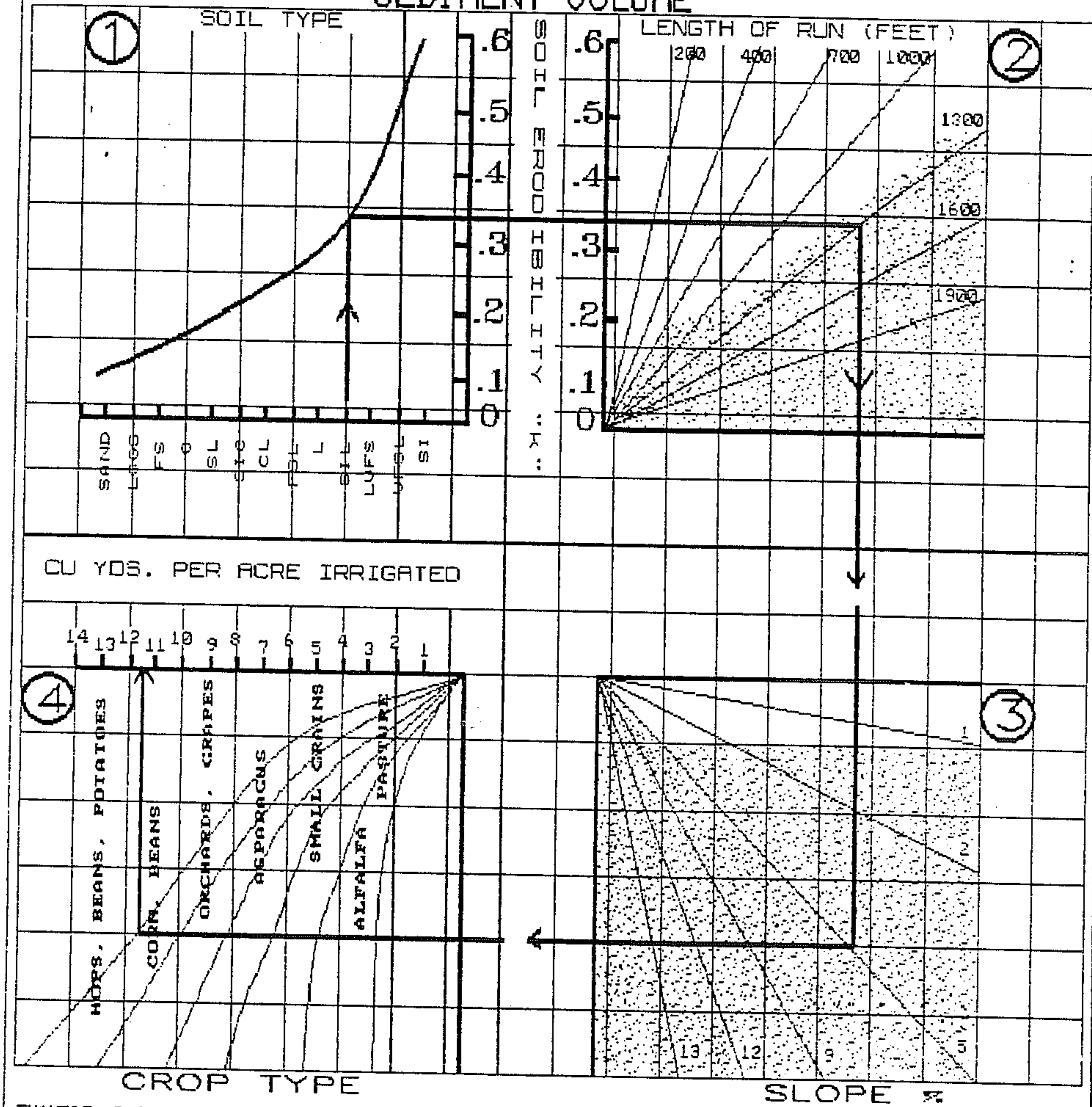
Study Area Farming Practices

Seven farming practices commonly used by West-side farmers have been identified as having impacts on irrigation tailwater volume and quality. The seven practices are: 1) pre-irrigation; 2) germination irrigation; 3) irrigation stream size and length of run; 4) earthen water supply and drain ditches; 5) cultivation; 6) depth of drainage ditches; 7) irrigation scheduling.

1) Pre-irrigation: Pre-irrigation is a practice where water is applied to bring the crop root zone to field capacity prior to planting. The majority of row crops grown in the study area receive a pre-irrigation. These crops require pre-irrigation since it is difficult to maintain required levels

FIGURE 2: YAKIMA SPECIAL STUDY

NOMOGRAPH NO. 1
SEDIMENT VOLUME



EXAMPLE: Determine sediment yield on a 40 acre field of potatoes in a silt loam soil with a 5% slope, and an irrigation furrow length of 1300 ft.
SEDIMENT = 11.5 CU YDS. per acre x 40 acres = 460 CU. YDS.

Shaded areas indicate care should be used to surface irrigate.

SOURCE: USDA-SCS

of soil moisture during periods of peak evapotranspiration. Experience has shown that crop yields can decrease without pre-irrigation. Unfortunately, these irrigations tend to be excessive with large stream sizes applied for long durations. The resulting irrigation runoff is large and often laden with suspended solids. Table 7 shows water samples taken from two pre-irrigations within the Spanish Grant Drainage District. The samples indicate that preirrigation with a sprinkler system can significantly reduce the amount of tailwater produced. Both flow and the concentration of suspended sediment in tailwater were considerably greater when preirrigation was done by the furrow method.

2) Germination Irrigation: This type of irrigation is used in the study area when it is necessary to have high soil moisture in close contact with the seed to insure crop germination and early growth. Like pre-irrigations, germination irrigations are often of long duration and result in excessive applications and runoff. Many of the soil types in the study area are fine in texture and have slow infiltration rates. Given low cost water, labor and management concerns, water is often applied liberally in order to minimize the cost of irrigation. Cultivation before irrigations results in surface conditions where soil particles are readily detached and transported with tailwater.

Another common method used to germinate crops in the study area is to sprinkle irrigate using a hand move system. Pre-irrigations and germination irrigations conducted with hand move sprinklers can considerably reduce tailwater quantity and improve quality due to more uniform water application which more closely approximates the soils intake rate. A major drawback of this system is that a pressurized pipeline system is needed, and there is an extra cost to purchase or rent and use such equipment.

3) Irrigation Water Stream Size and Length of Run: The longer the length of run a farmer utilizes the larger the stream size must be in order to distribute water more uniformly throughout the field. Unfortunately, a large stream size is sometimes necessary to insure water reaches the lower portions of a large field in a reasonable length of time.

On these fields stream size often exceeds maximum non-erosive flow resulting in erosion, sediment delivery and deposition both within and off the field. The greatest erosion tends to be at the top of the furrow where the stream sizes are largest. While shorter irrigation runs can use smaller stream sizes to irrigate uniformly, there are some drawbacks to their use. Shorter runs require more frequent cross irrigation and drain ditches in order to maintain a high distribution uniformity. These ditches can result in increased labor costs, interfere with tillage, seeding, cultivating and harvesting operations.

TABLE 7 PRE-IRRIGATION SUSPENDED SEDIMENT & FLOW LEVELS
1988 USDA-SCS FIELD DATA

Pre-irrigation: Sprinkler Crop: Tomatoes

Date	Flow/cfs	Sus Sed mg/l	Tons Sediment in 24 hours	Sample Site	% Sediment removed
4/5	.1	180	.05	Ditch	
4/5	.1	71	.02	Sump	62
4/6	.4	500	.52	Ditch	
4/6	.4	310	.33	Sump	38
4/7	.2	170	.09	Ditch	
4/7	.2	100	.05	Sump	42

Pre-irrigation: Furrow Crop: Walnuts

Date	Flow/cfs	Sus Sed mg/l	Tons Sediment in 24 hours	Sample Site	% Sediment removed
4/5	.4	3,500	3.68	Ditch	
4/5	.4	140	.19	Sump	95
4/6	.3	2,200	1.87	Ditch	
4/6	.3	210	.18	Sump	91
4/7	.9	1,700	4.26	Ditch	
4/7	.9	550	1.38	Sump	68

4) Earthen Supply and Drain Ditches: The widespread use of earthen supply and drain ditches adds to the non-point source water quality problem. Earthen channels are susceptible to erosion when flow velocities are high. Although not as large a sediment contributor as the furrows, a significant amount can be generated when irrigation waters are not closely controlled.

5) Cultivation: Cultivation and tillage operations are widely used by West-side farmers to control weeds, diseases and pests, shatter compacted layers and improve water infiltration. Cultivation is an important factor in the destruction of soil aggregates and structure which facilitates detachment of soil particles. The resulting soil aggregates are smaller in size and are more easily detached and transported by irrigation waters.

6) Depth of Drain Ditches: Farmers in the study area commonly dig their drain ditches 5 to 10 inches deeper than the supply furrows they drain. These ditches are cut at a slope that allows tailwater to flow away quickly. This practice essentially creates a knick point or "head cut" which causes the ends of the furrows to erode rapidly upstream and into the field. As erosion moves up the furrows with successive irrigations the slope at the lower end of the field effectively increases. A properly dug ditch and tailwater management can control this erosion problem.

7) Irrigation Scheduling: In order to achieve the best use of our water resources while also achieving economical crop yields, irrigations need to be properly scheduled. In the study area farmers use a wide variety of methods to schedule irrigations. Excess crop irrigations due to poor scheduling wastes good quality irrigation water while at the same time increasing tailwater and sediment export. Although many tools are available to monitor crop water requirements, many irrigators still irrigate inefficiently. A few of the reasons for poor IWM are: 1) inconvenience and skill 2) lack of technical knowledge 3) poor irrigation system design 4) lack of capital for system improvements 5) lack of incentive to conserve water due to low water prices. Until these factors are addressed inefficient water use will remain a persistent problem.

CHAPTER V

MAGNITUDE AND FREQUENCY OF TAILWATER DISCHARGES BY SOURCE

Total sediment delivery is related to the magnitude, duration, and frequency of discharge into receiving waters. Both the flow rate and sediment load for an individual drain is highly variable since both may be influenced by either human or natural disturbance in the basin. Factors include rainfall, land-use (including crop rotation), availability and quantity of irrigation water, irrigation water management, geologic conditions in the area, and topography. The exact impact of sedimentation on receiving waters is not precisely known and in general only turbidity standards have been established. However, many of the potentially harmful effects of sediment loading have been identified such as inhibiting light penetration, changing water temperature, blanketing stream bottoms, and retaining organics and other toxics. The combination of these effects can be extremely harmful to an aquatic environment.

To assess the impacts of agricultural drainage on the San Joaquin River, sampling programs have been instituted by various agencies over the past several years. Data from the Regional Water Quality Control Board (RWQCB) Sampling Program are shown in Tables 8 and 9. Sampling done by Stanislaus County and SCS personnel are Shown in Table 10. The purpose of the monitoring programs included identification of typical irrigation season duration, to establish an estimate of flow from each drain and to estimate total sediment delivery through measurement of Total Suspended Solids (TSS). In order to supplement this data and to achieve better coverage during the July-August peak use period, additional weekly samples were collected in 1988 by SCS staff from 17 of the original 26 drains. The results of this sampling are shown in Table 11.

The RWQCB sampling was done over a period from April 1985 through December 1987. The main purpose of the sampling was to gather data on dissolved elements in the drain water and not to measure sediment yield. Thus, there are significant gaps in flow data. The distribution of average flow and sediment for the period are shown in Figure 3. It is interesting to note the disparity between average sediment loading and average flow for these data. For example, drains 019, 021 and 026 produce 42 percent of the flow but only about 7 percent of the sediment yield. Much of this discrepancy may be explained by the gaps in the flow sampling data. Other points to note about the data are the extreme variation in TSS and flow for each sampling site. Drain 030 produces approximate 13 percent of the total average sediment with TSS readings varying from 156 mg/l to 4900 mg/l with an average of 1280 mg/l. The second trend to note is the cyclical nature of

TABLE 8 WEST-SIDE DRAINS FLOW DATA (cfs) 4-85 TO 12-87 (SOURCE RWQCB)

TION	12/21/87	10/20/87	08/20/87	07/16/87	06/18/87	05/19/87	04/20/87	02/19/87	12/19/86	11/21/86	10/16/86	09/18/86	08/18/86	07/17/86	06/18/86	05/20/86	04/15/85	AVERAGE
)51	NR	NR	7.6	17.5	10.6	8.9	2.3	0.3	4.3	NR	NR	6	8.9	NR	4.5	3	NR	6.7
)44	NR	NR	8.7	4.5	2	2	2.8	NR	NR	0.3	NR	NR	4.4	1.8	NR	NR	NR	2.7
)43	NR	NR	5	5.3	9	2.8	8.7	NR	0.1	1.8	NR	9	13	5	7.5	2.5	NR	5.4
)42	NR	NR	6.2	11.6	28.7	13	NR	NR	4	NR	0.1	NR	35	NR	7	NR	6	11.2
)40	0.8	NR	16	15.2	15	12	27	NR	2	NR	NR	10	NR	NR	12.5	NR	NR	11.0
)36	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	10	NR	NR	10.0
)34	NR	NR	NR	7	3	3	NR	NR	0.3	NR	NR	NR	9.6	5	6	NR	3	3.9
)31	NR	NR	5.6	5.6	4.25	11.5	8.3	NR	7.5	NR	NR	NR	26.9	30	NR	2	NR	11.3
)30	NR	NR	6.5	9.5	8	9	5	1	2.5	NR	3.5	6	12	9	6	2	5	6.1
)29	NR	NR	10.5	10	9	NR	24	1	NR	NR	NR	NR	12	25	10	7	5	11.4
)28	NR	NR	NR	0.3	4.1	1.1	0.4	NR	NR	NR	1.5	5	6.5	12	NR	5	2	3.4
)27	NR	NR	0.1	7	8	3	4.5	NR	.33	NR	NR	7	7.5	NR	NR	12	2	5.1
)26	NR	NR	58.5	47	27	22.4	13.3	NR	15.6	7.5	6	10	15.5	20	20	10	14	20.5
)50	NR	NR	3.5	3.5	2	1.5	NR	NR	NR	NR	NR	1	4	4	0.2	NR	NR	2.2
)25	NR	NR	3	2	3.5	0.1	0.7	NR	NR	NR	NR	NR	2.5	10	7	NR	NR	3.6
)24	0.3	NR	10	20.5	14	10	20	NR	4.5	NR	NR	8	16	14	13	1.5	NR	11.0
)23	NR	NR	2.1	8	12	1.9	2.5	NR	2.3	0.1	NR	8	2.1	6.1	4	2.5	4	4.3
)22	NR	NR	6.5	NR	6.5	5	NR	NR	NR	NR	NR	2.5	NR	NR	13.5	NR	NR	6.8
)21	0.5	NR	35.5	42.6	30.7	NR	51	NR	10.6	13.5	NR	18	45.6	65	25	NR	NR	30.7
)53	NR	NR	3.5	3.5	4	NR	NR	0.5	NR	NR	NR	NR	NR	NR	NR	NR	NR	2.9
19	0.5	NR	81.2	103	74.5	NR	NR	NR	0.5	NR	30	107	98.8	112	66	12	NR	62.3
52	NR	NR	14	9	14.5	NR	NR	3	4.5	3	NR	NR	NR	NR	NR	NR	NR	8.0
17	NR	NR	3.9	4	1.5	NR	NR	NR	1	3	NR	2	5.3	10	9	NR	NR	4.4
16	NR	NR	11.5	2	5.5	13	NR	NR	NR	NR	NR	NR	7.1	NR	NR	2.5	NR	6.9
15	NR	NR	9	3	4	4	NR	NR	0.3	NR	NR	0.3	1.5	1	4	0.8	NR	2.8
14	NR	NR	4	1.6	3.6	4.5	NR	NR	NR	NR	NR	NR	1.5	4.5	4.5	4	NR	7.6

NO READINGS TAKEN

TABLE 9 WEST-SIDE DRAINS TSS DATA (mg/l) 4-85 TO 12-87 (SOURCE RWQCB)

STATION	12/21/87	10/20/87	08/20/87	07/16/87	06/18/87	05/19/87	04/20/87	02/19/87	12/19/86	11/21/86	10/16/86	09/18/86	08/18/86	07/17/86	06/18/86	05/20/86	04/15/85	AVERAGE
051	NR	59	760	890	362	288	14	8	114	20	20	184	52	420	352	38	NR	222
044	22	190	150	220	44	24	36	10	NR	12	NR	102	20	258	NR	NR	NR	91
043	12	330	460	420	584	254	402	24	2	2066	32	252	316	756	183	706	NR	425
042	NR	130	800	1300	1180	776	559	8	252	NR	2	284	160	546	246	3410	246	639
040	3	93	590	1400	1712	560	600	2	28	12	254	584	NR	NR	608	NR	860	522
036	210	72	560	510	366	308	96	82	146	196	4	450	116	388	155	NR	NR	244
034	NR	NR	NR	2400	1762	560	NR	NR	12	NR	NR	NR	332	484	396	NR	1812	970
031	NR	NR	1200	2900	220	1216	928	NR	216	NR	NR	NR	60	355	110	532	2042	889
030	NR	10	4400	4900	1280	1468	174	456	106	NR	844	156	334	1314	1920	676	1118	1277
029	NR	5	720	2600	376	240	391	8	70	19	14	100	198	1050	126	482	158	410
028	NR	280	320	2400	240	858	1006	NR	NR	NR	140	234	158	1950	NR	266	586	703
027	NR	NR	6	2000	1462	238	586	NR	66	NR	NR	92	720	734	658	1550	890	750
026	NR	26	100	180	322	122	134	12	220	14	626	92	120	566	188	36	NR	184
050	NR	2	220	260	80	896	80	NR	NR	NR	NR	56	124	154	142	NR	NR	201
025	NR	NR	1100	270	192	108	20	NR	NR	NR	NR	NR	100	344	200	NR	1556	432
024	2	4	700	730	1242	340	238	4	300	10	6	122	194	536	340	722	NR	342
023	NR	14	23	34	65	88	10	NR	68	42	56	80	106	34	165	554	94	96
022	NR	NR	110	180	74	28	NR	14	88	92	NR	116	270	35	200	123	NR	111
021	4	210	630	780	154	226	862	38	88	92	NR	82	106	360	226	122	NR	265
053	NR	33	920	120	136	192	NR	24	NR	NR	NR	NR	NR	NR	NR	NR	NR	238
019	3	12	250	380	295	128	NR	18	80	4	50	110	261	334	358	110	272	167
052	NR	240	920	380	464	408	NR	410	212	2	NR	NR	NR	NR	NR	NR	NR	380
017	NR	NR	290	490	468	182	NR	NR	74	4	NR	28	172	155	312	2	NR	198
016	NR	36	380	72	154	114	NR	NR	NR	NR	NR	48	420	NR	182	58	NR	163
015	NR	NR	6	10	74	66	NR	NR	80	4	NR	50	212	90	110	42	NR	68
014	NR	19	53	33	90	82	NR	NR	NR	NR	NR	NR	60	24	128	78	NR	55

NR: NO READINGS TAKEN

TABLE 10 WEST-SIDE DRAINS FLOW & TSS DATA 6/76 TO 10/79
(SOURCE: USDA-SCS FIELD DATA)

	FLOW/cfs		TSS (mg/l)	
	DRAIN No.		DRAIN No.	
DATE	26	22	26	22
10/79	0	8.4	0	44
9/79	16.2	10.2	22	72
8/79	32.1	21.5	22	83
7/79	28.7	22.9	312	153
6/79	30.9	26.3	217	160
5/79	31.5	24.3	242	68
4/79	22.2	24.9	195	104
3/79	14.6	17.2	64	344
2/79	7.9	0	12	0
1/79	0	0	0	0
12/78	0	0	0	0
11/78	1.5	0	25	0
10/78	4.2	2.1	5	19
9/78	8.4	11.1	9	123
8/78	15.5	24.5	94	156
7/78	16.8	27.6	317	155
6/78	16.1	40.3	289	178
5/78	19.8	0	126	84
4/78	15.1	0	8	56
3/78	21.8	0	24	44
2/78	38.8	0	20	33
1/78	8.7	3.9	10	39
12/77	1.1	1.6	24	56.5
11/77	4.5	38	48.8	44.6
10/77	3.4	0.5	7.4	623
9/77	3.11	2.1	58.3	109.7
8/77	20.8	11.8	269.2	104.7
7/77	18.1	4.4	518.3	96
6/77	22.2	6.8	983.3	162.4
5/77	15.6	10.6	247.5	120
4/77	25.2	12	3600	139
3/77	26	8.5	180	418
2/77	16.9	8.5	141	75.6
1/77	6.3	2.1	49	44
12/76	0.5	0.5	24	250
11/76	0.5	0.5	4.5	12
10/76	6.5	0.1	65	39
9/76	21.2	11.3	358	56.5
8/76	15	10.1	303	66.3
7/76	21.7	15.6	272	253
6/76	14.5	7.1	354	210

SAMPLE SITE 26: DEL PUERTO CREEK

SAMPLE SITE 22: RAMONA LAKE

TABLE 11 WEEKLY FLOW AND SEDIMENT YIELD, WEST STANISLAUS MAIN DRAINS

SITE DESCRIPTION	STATION/DATE	7/5/88 FLOW cfs	7/5/88 TSS mg/l	7/5/88 *SEDIMENT tons	7/11/88 FLOW cfs	7/11/88 TSS mg/l	7/11/88 *SEDIMENT tons
AZVEDO ROAD DRAIN	015				15.90	70.00	3.0
UNNAMED TAILWATER DRAIN	016				2.00	63.00	0.3
FREITAS ROAD DRAIN	017				1.90	480.00	2.5
ORESTIMBA CREEK	019				18.80	490.00	24.8
RAMONA LAKE DRAIN	022	4.60	190.0	2.4	4.30	130.00	1.5
EUCALYPTUS AVENUE DRAIN	025	1.90	800.0	4.1	2.60	880.00	6.2
DEL PUERTO CREEK	026	18.10	750.0	36.5	12.00	280.00	9.0
RICHIE SLOUGH DRAIN	027	4.70	2400.0	30.4	14.00	160.00	6.0
DEL MAR DRAIN	028	10.00	1600.0	43.1	7.60	1600.00	32.7
WESTLY WASTEWAY	029				22.00	320.00	18.9
GRAYSON ROAD DRAIN	030	3.30	180.0	1.6	2.00	1400.00	7.5
HAGGERMAN DRAIN	036	59.00	320.0	50.8	14.80	900.00	35.8
INGRAM CREEK	040	17.40	2500.0	117.1	9.40	1000.00	25.3
HOSPITAL CREEK	042	4.50	1100.0	13.3	1.60	350.00	1.5
CENTER ROAD DRAIN	043	1.80	73.0	0.4	6.30	230.00	3.9
EL SOLYO MAIN DRAIN	044				0.10	170.00	0.0
BLEWETT DRAIN	051	4.40	860.0	10.2	15.80	1100.00	46.8

SITE DESCRIPTION	STATION/DATE	7/18/88 FLOW cfs	7/18/88 TSS mg/l	7/18/88 *SEDIMENT tons	7/25/88 FLOW cfs	7/25/88 TSS mg/l	7/25/88 *SEDIMENT tons
AZVEDO ROAD DRAIN	015	0.36	36.0	0.0	9.70	30.0	0.8
UNNAMED TAILWATER DRAIN	016	0.10	44.0	0.0	4.10	270.0	3.0
FREITAS ROAD DRAIN	017	26.20	270.0	19.0	0.30	210.0	0.2
ORESTIMBA CREEK	019	40.00	1300.0	139.9	44.20	310.0	36.9
RAMONA LAKE DRAIN	022	8.20	34.0	0.8	10.20	85.0	2.3
EUCALYPTUS AVENUE DRAIN	025	0.10	68.0	0.0	0.40	110.0	0.1
DEL PUERTO CREEK	026	15.40	190.0	7.9	5.30	140.0	2.0
RICHIE SLOUGH DRAIN	027	10.60	580.0	16.5	0.80	240.0	0.5
DEL MAR DRAIN	028	0.90	2000.0	4.8	7.00	930.0	17.5
WESTLY WASTEWAY	029	22.30	1400.0	84.0	22.10	800.0	47.6
GRAYSON ROAD DRAIN	030	2.00	760.0	4.1	2.00	770.0	4.1
HAGGERMAN DRAIN	036	59.00	500.0	79.4	59.00	520.0	82.6
INGRAM CREEK	040	15.00	990.0	40.0	18.70	2300.0	115.7
HOSPITAL CREEK	042	12.20	1000.0	32.8	11.50	500.0	15.5
CENTER ROAD DRAIN	043	4.80	450.0	5.8	2.30	350.0	2.2
EL SOLYO MAIN DRAIN	044	1.90	330.0	1.7	5.20	220.0	3.1
BLEWETT DRAIN	051	10.60	160.0	4.6	5.30	100.0	1.4

TABLE 11 WEEKLY FLOW AND SEDIMENT YIELD, WEST STANISLAUS MAIN DRAINS

SITE DESCRIPTION	STATION/DATE	8/01/88 FLOW cfs	8/01/88 TSS mg/l	8/01/88 *SEDIMENT tons	8/08/88 FLOW cfs	8/08/88 TSS mg/l	8/08/88 *SEDIMENT tons
AZVEDO ROAD DRAIN	015	10.60	24.0	0.7	3.90	52.0	0.5
UNNAMED TAILWATER DRAIN	016	0.80	140.0	0.3	3.00	290.0	2.3
FREITAS ROAD DRAIN	017	2.50	380.0	2.6	0.50	200.0	0.3
ORESTIMBA CREEK	019	36.00	360.0	34.9	51.80	480.0	66.9
RAMONA LAKE DRAIN	022	4.60	96.0	1.2	12.80	140.0	4.8
EUCALYPTUS AVENUE DRAIN	025	3.00	400.0	3.2	6.90	160.0	3.0
DEL PUERTO CREEK	026	15.00	230.0	9.3	15.90	180.0	7.7
RICHIE SLOUGH DRAIN	027	4.00	3100.0	33.4	4.70	790.0	10.0
DEL MAR DRAIN	028	7.80	3000.0	63.0	7.50	2500.0	50.5
WESTLY WASTEWAY	029	18.90	590.0	30.0	10.60	650.0	18.5
GRAYSON ROAD DRAIN	030	2.80	3600.0	27.1	1.80	1500.0	7.3
HAGGERMAN DRAIN	036	14.80	640.0	25.5	14.80	370.0	14.7
INGRAM CREEK	040	10.20	2900.0	79.6	10.40	950.0	26.6
HOSPITAL CREEK	042	9.60	670.0	17.3	11.40	390.0	12.0
CENTER ROAD DRAIN	043	2.10	640.0	3.6	2.70	720.0	5.2
EL SOLYO MAIN DRAIN	044	1.90	130.0	0.7	8.90	230.0	5.5
BLEWETT DRAIN	051	8.50	1100.0	25.2	13.30	1100.0	39.4

SITE DESCRIPTION	STATION/DATE	8/15/88 FLOW cfs	8/15/88 TSS mg/l	8/15/88 *SEDIMENT tons	8/22/88 FLOW cfs	8/22/88 TSS mg/l	8/22/88 *SEDIMENT tons
AZVEDO ROAD DRAIN	015	3.10	60.0	0.5	4.80	76.0	1.0
UNNAMED TAILWATER DRAIN	016	0.40	97.0	0.1	1.40	330.0	1.2
FREITAS ROAD DRAIN	017	2.70	140.0	1.0	0.00	0.0	0.0
ORESTIMBA CREEK	019	36.70	370.0	36.5	46.10	270.0	33.5
RAMONA LAKE DRAIN	022	8.10	180.0	3.9	5.30	23.0	0.3
EUCALYPTUS AVENUE DRAIN	025	0.00	12.0	0.0	3.90	7800.0	81.9
DEL PUERTO CREEK	026	5.00	100.0	1.3	5.50	83.0	1.2
RICHIE SLOUGH DRAIN	027	10.40	360.0	10.1	1.20	47.0	0.2
DEL MAR DRAIN	028	1.70	1900.0	8.7	7.70	900.0	18.6
WESTLY WASTEWAY	029	16.20	790.0	34.4	10.20	580.0	15.9
GRAYSON ROAD DRAIN	030	6.90	790.0	14.7	1.70	3900.0	17.8
HAGGERMAN DRAIN	036	59.00	250.0	39.7	14.80	290.0	11.5
INGRAM CREEK	040	8.70	780.0	18.3	9.40	890.0	22.5
HOSPITAL CREEK	042	11.40	510.0	15.6	10.70	2700.0	77.7
CENTER ROAD DRAIN	043	1.10	770.0	2.3	6.50	180.0	3.1
EL SOLYO MAIN DRAIN	044	0.02	1500.0	0.1	2.20	90.0	0.5
BLEWETT DRAIN	051	14.30	420.0	16.2	4.50	280.0	3.4

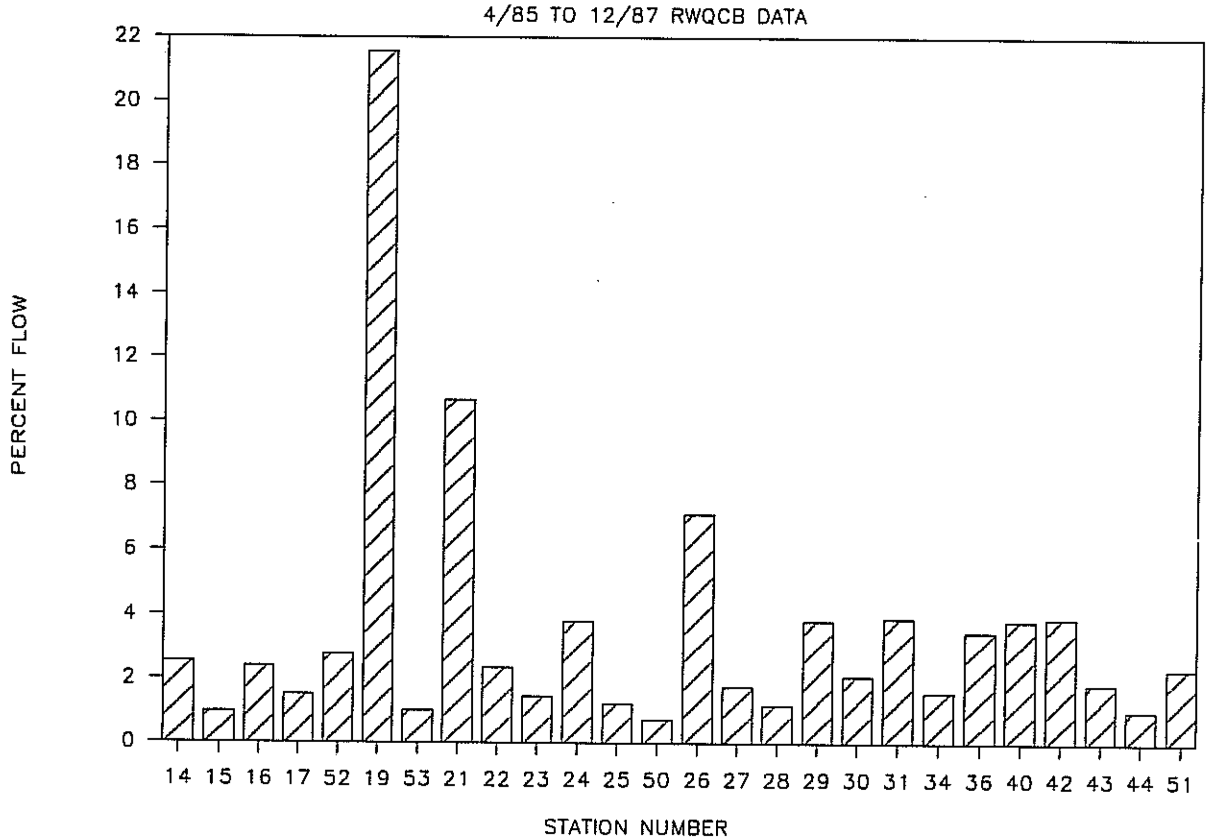
TABLE 11 WEEKLY FLOW AND SEDIMENT YIELD, WEST STANISLAUS MAIN DRAINS

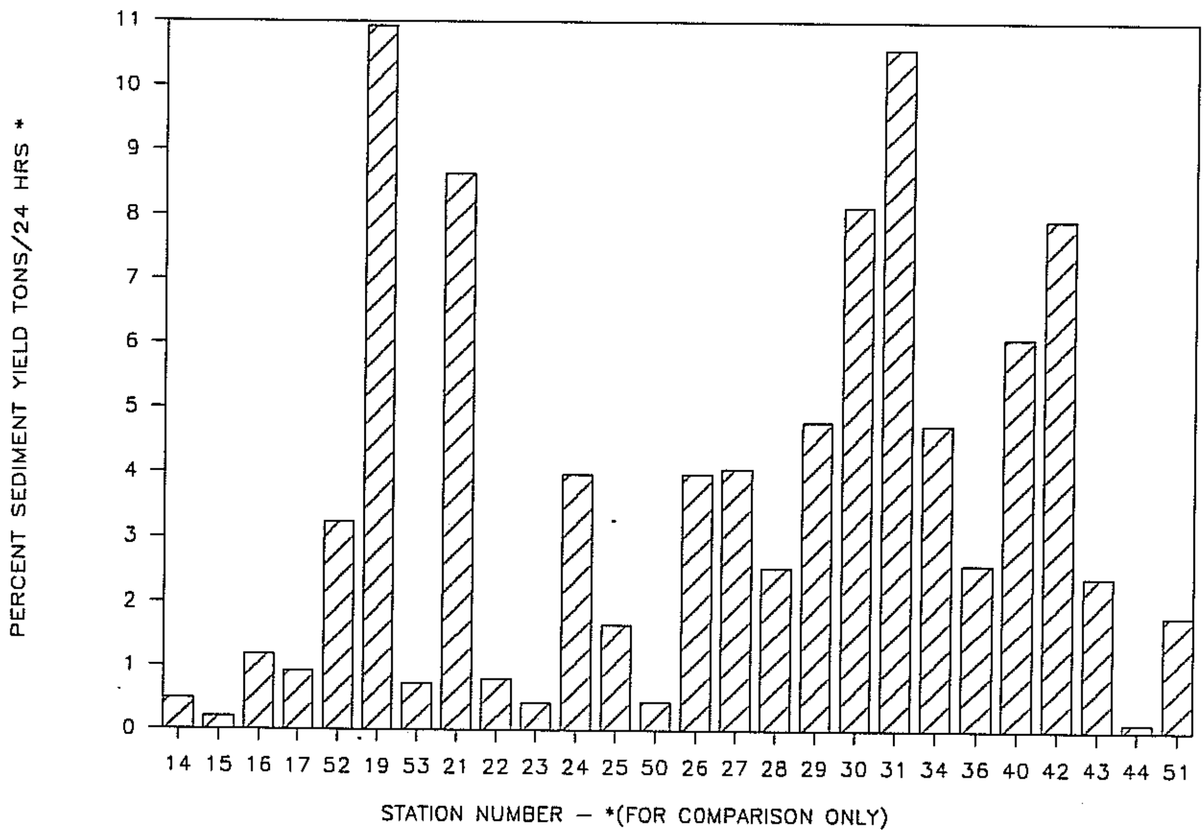
SITE DESCRIPTION	STATION/DATE	FLOW cfs	8/29/88 TSS mg/l	*SEDIMENT tons	AVERAGE FLOW cfs	AVERAGE TSS mg/l	**AVERAGE SEDIMENT tons
AZVEDO ROAD DRAIN	015	6.90	70.0	1.3	6.9	52	1.0
UNNAMED TAILWATER DRAIN	016	8.40	150.0	3.4	1.7	173	0.8
FREITAS ROAD DRAIN	017	0.00	0.0	0.0	4.9	210	2.8
ORESTIMBA CREEK	019	28.40	140.0	10.7	39.1	465	48.9
RAMONA LAKE DRAIN	022	9.60	110.0	2.8	7.3	110	2.1
EUCALYPTUS AVENUE DRAIN	025	0.00	11.0	0.0	2.1	1138	6.4
DEL PUERTO CREEK	026	4.30	46.0	0.5	10.7	222	6.4
RICHIE SLOUGH DRAIN	027	1.70	470.0	2.1	5.8	905	14.1
DEL MAR DRAIN	028	3.40	650.0	5.9	6.0	1676	26.9
WESTLY WASTEWAY	029	8.10	430.0	9.4	14.5	695	27.1
GRAYSON ROAD DRAIN	030	1.50	570.0	2.3	2.7	1497	10.8
HAGGERMAN DRAIN	036	59.00	390.0	61.9	39.4	464	49.2
INGRAM CREEK	040	7.60	650.0	13.3	11.9	1440	46.0
HOSPITAL CREEK	042	13.40	460.0	16.6	9.6	853	22.0
CENTER ROAD DRAIN	043	2.80	170.0	1.3	3.4	398	3.6
EL SOLYO MAIN DRAIN	044	0.20	410.0	0.2	2.3	385	2.4
BLEWETT DRAIN	051	8.20	610.0	13.5	9.4	637	16.2

* ESTIMATE BASED ON CONSTANT LEVELS OF TSS & FLOW FOR 24 HOURS.
** FOR COMPARISON PURPOSES ONLY
SOURCE: USDA-SCS 1988 FIELD DATA

FIGURE 3 FLOW AND SEDIMENT DISTRIBUTION

4/85 TO 12/87 RWQCB DATA





TSS and flow with increasing flow and TSS during the summer irrigation season. Since there are many gaps in the sample data for the winter months it should be stated that it is important to realize that severe winter storm have the capability to produce large quantities of sediment in short time periods.

The July-August weekly sample data was analyzed to determine both the distribution and magnitude of flow and sediment from the 17 drains selected. Figure 4 shows this distribution. Out of these 17 drains three drains (019, 036 and 040) were found to produce 51 percent of the total average weekly flow and 50 percent of the 24 hour estimated sediment yield. If the RWQCB data (representing all 26 drains) is used, these same drains produce only 10 percent of the sediment and 29 percent of the flow. For these drains there is considerable fluctuation in both flow and TSS. However, for these three drains, (019, 036, and 040) as flow levels increase so do TSS readings. Table 12 shows the flow and sediment range for both SCS and RWQCB data. Figures 5 and 6 show plots of weekly flow data for drains 19, 36, and 40 and the weekly average for all drains for the nine week sampling done specifically for this report. The weekly variation of flow and particularly TSS reading from sampling is very high. If an average value for the period is used some smoothing results. Nonetheless, there are still large swings in both flow and TSS from each "sporadic sample". Much of the variation may be explained by the cyclical and seasonal nature of irrigated agriculture in the study area. Figure 7 shows the weekly fluctuations in average flow for typical West-side drains.

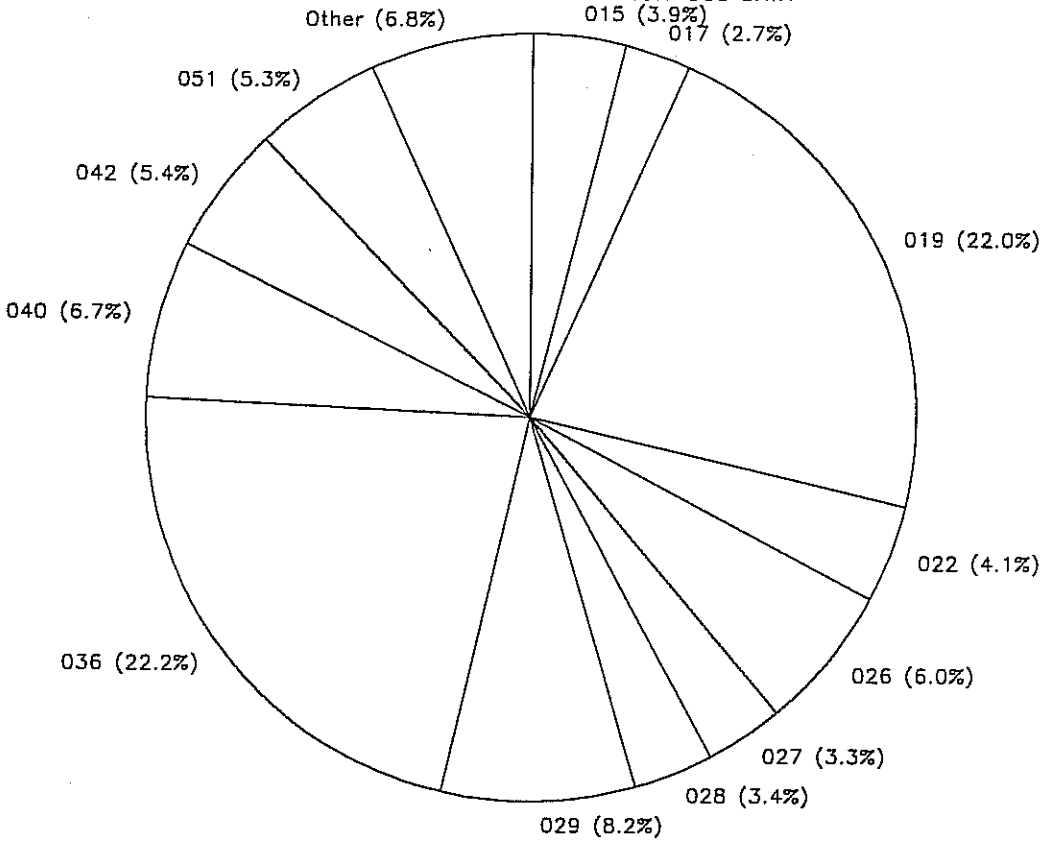
At this time there are no quantitative water quality standards for agricultural drainwater for either total tons of sediment yield allowed for each drain or an acceptable TSS level. Nevertheless, to illustrate the variability of sediment loading and the possible effects of any overall watershed management plan, the average weekly TSS reading for each drain was compared to an arbitrary 300 mg/l standard and to readings from the Spanish Grant Pilot Study Area. This comparison is shown in Figure 9.

Estimating total tonnage of sediment loading at the receiving water from a drainage basin can be done by several methods. For this study, drainage flow samples from 17 of the 26 identified drains were analyzed to determine TSS concentration and based on the drainage flows measured at the outlet to the San Joaquin during July and August 1988. Using this information, an estimate of total sediment yield tonnage was made. The results are shown in Table 11 and the weekly variation in Figure 8.

Due to limited time and manpower and the reconnaissance nature of the study, several simplifying assumptions were made

FIGURE 4 FLOW AND SEDIMENT DISTRIBUTION

AVERAGE ALL DRAINS – 1988 USDA-SCS DATA



SEDIMENT DISTRIBUTION

AVERAGE ALL DRAINS – 1988 USDA-SCS DATA

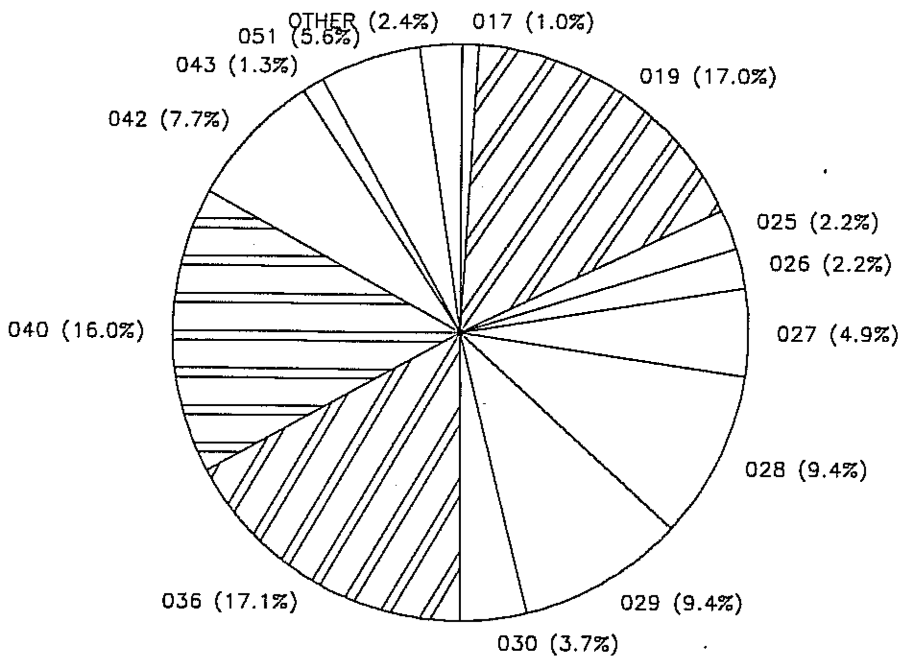
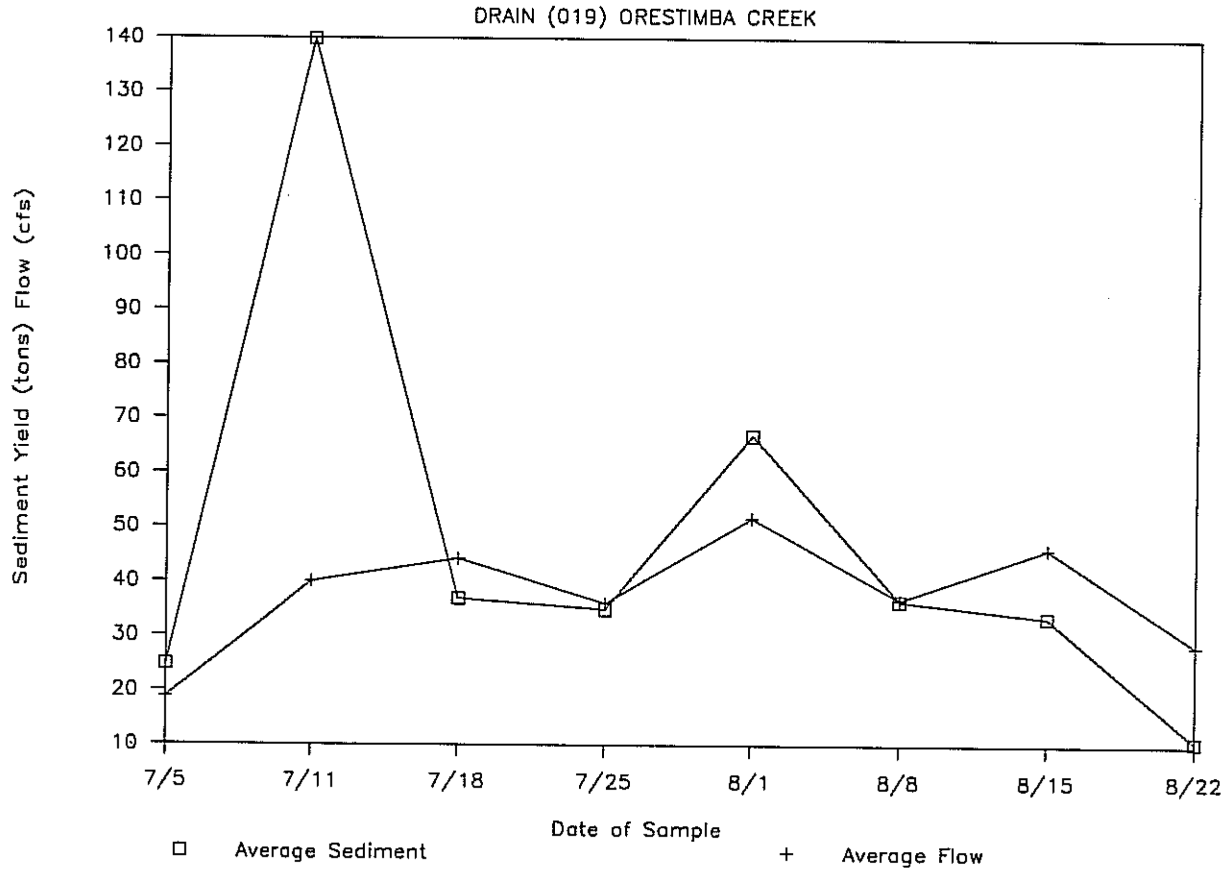


TABLE 12 COMPARISON OF SCS AND RWQCB FLOW AND TSS DATA
DRAINS 019, 036 & 040

DRAIN NUMBER	019	036	040
SCS FLOW (cfs)			
MINIMUM	19	15	9
AVERAGE	39	39	12
MAXIMUM	52	59	19
RWQCB FLOW (cfs)			
MINIMUM	0.5	0	0
AVERAGE	62	10	11
MAXIMUM (1)	103	10	27
SCS TSS (mg/l)			
MINIMUM	140	250	650
AVERAGE	465	464	1440
MAXIMUM	1300	900	2900
RWQCB TSS (mg/l)			
MINIMUM	3	4	2
AVERAGE	166	243	521
MAXIMUM (1)	380	560	1712

FIGURE 5 WEST-SIDE SEDIMENT AND FLOW



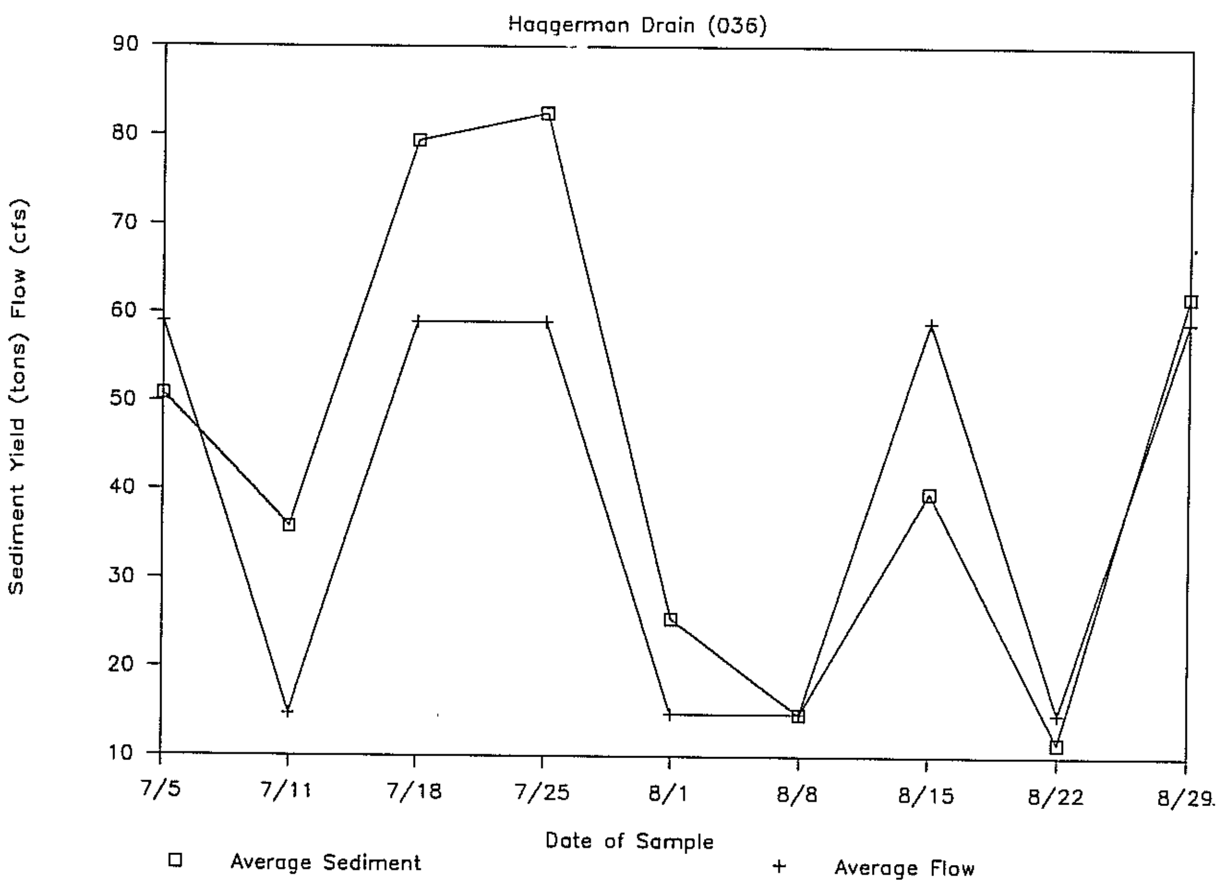
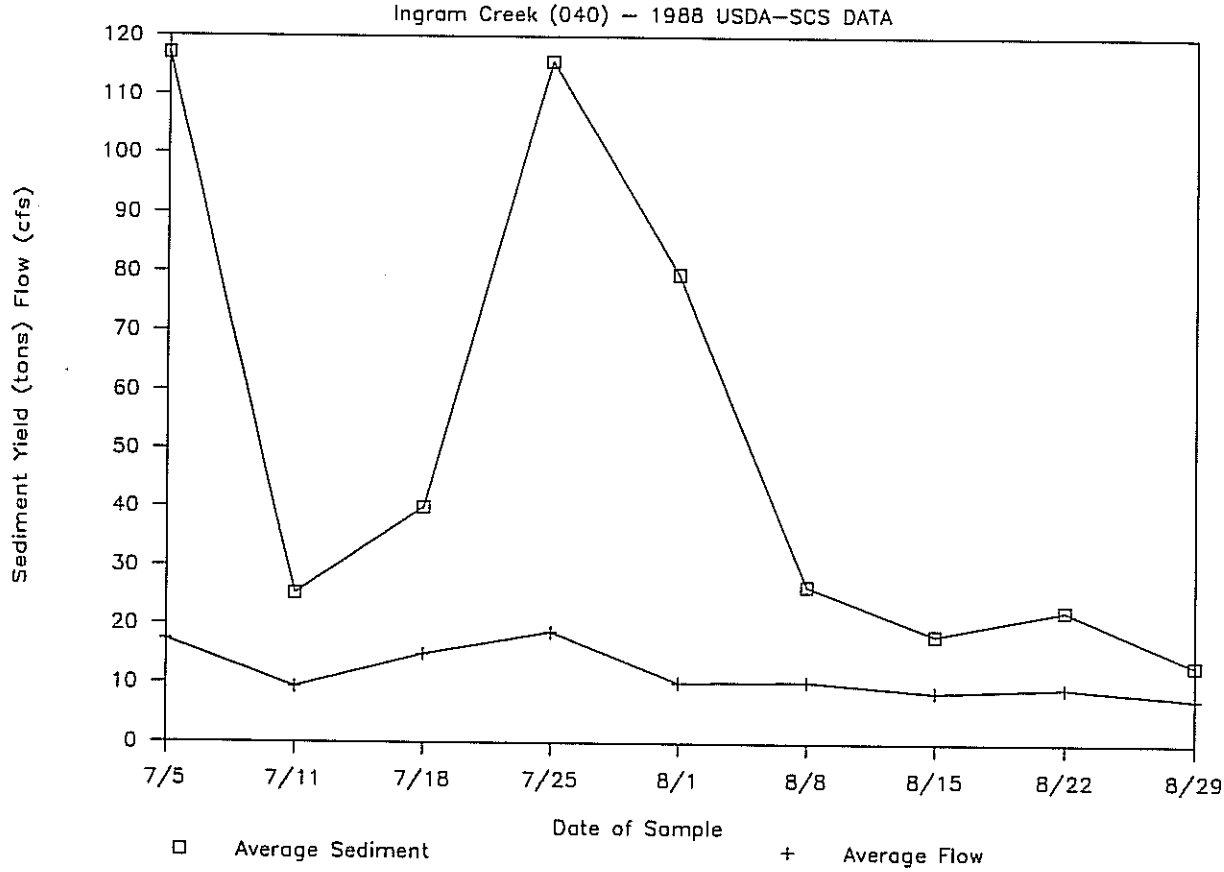


FIGURE 6 WEST-SIDE SEDIMENT AND FLOW



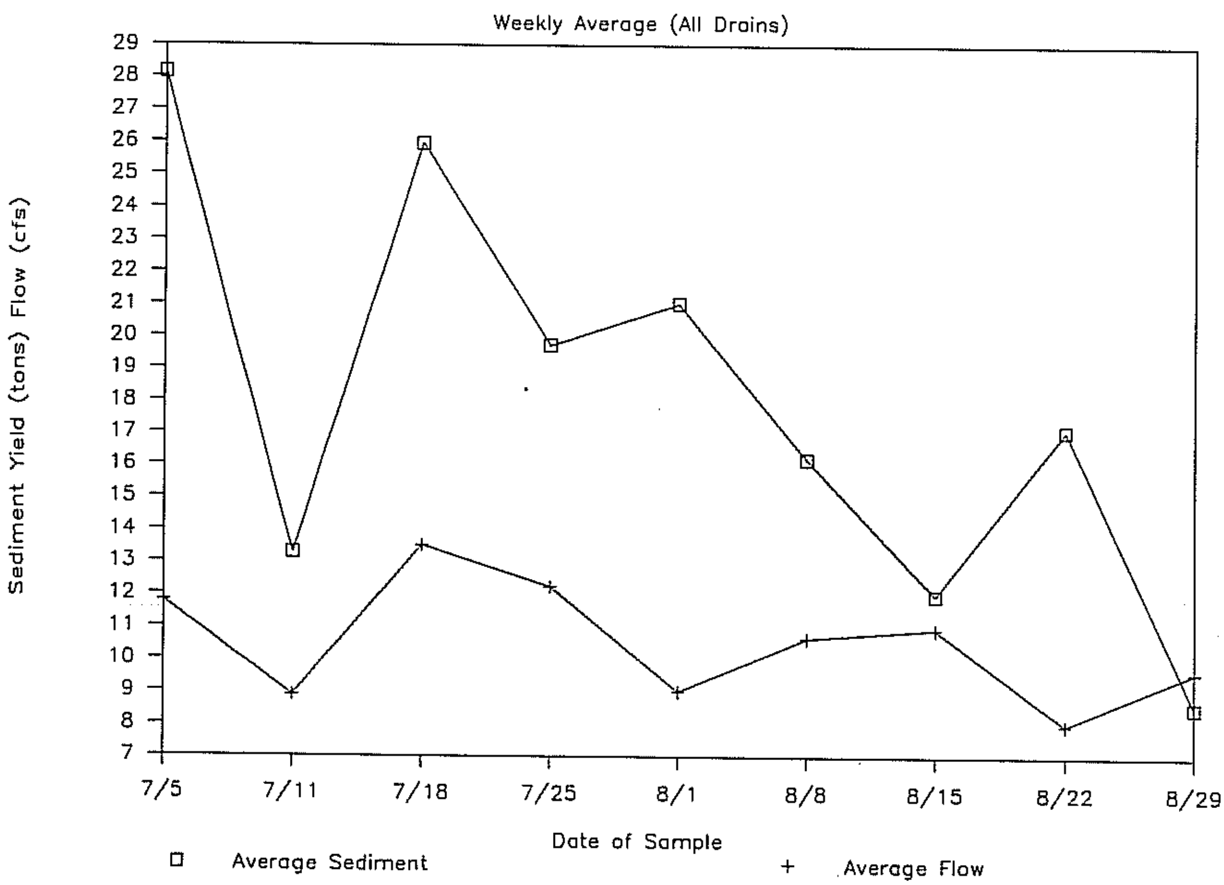


FIGURE 7 WEST-SIDE FLOWS

AVERAGE ALL DRAINS — 1988 USDA-SCS DATA

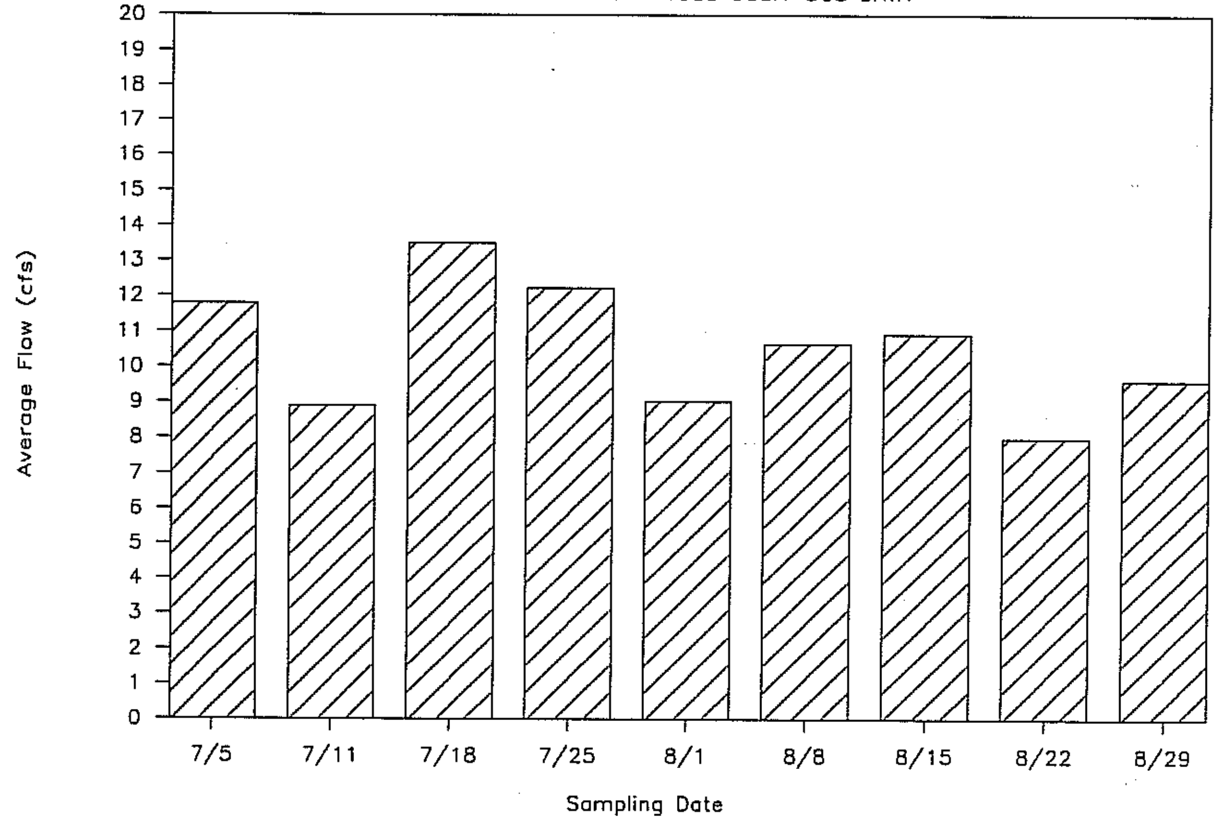


FIGURE 8 WESTSIDE SEDIMENT

AVERAGE ALL DRAINS — 1988 USDA-SCS DATA

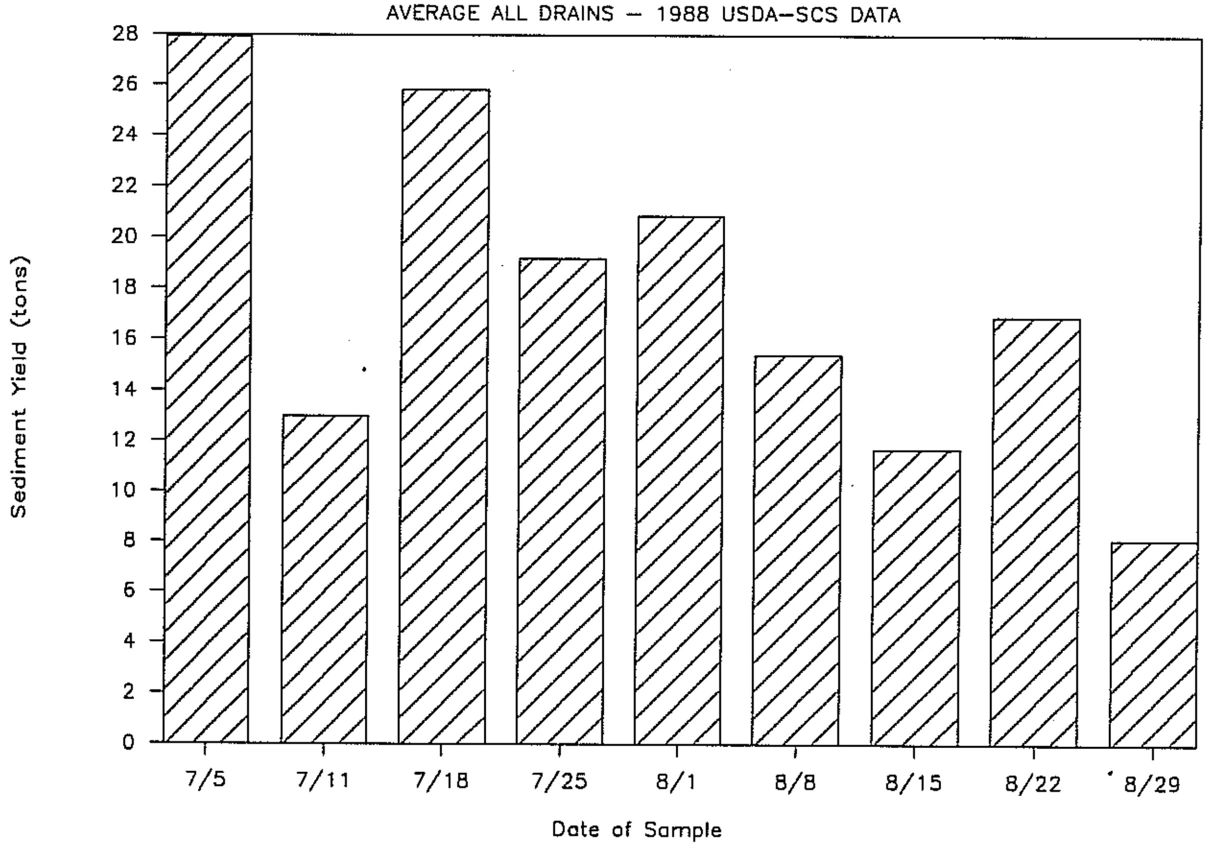
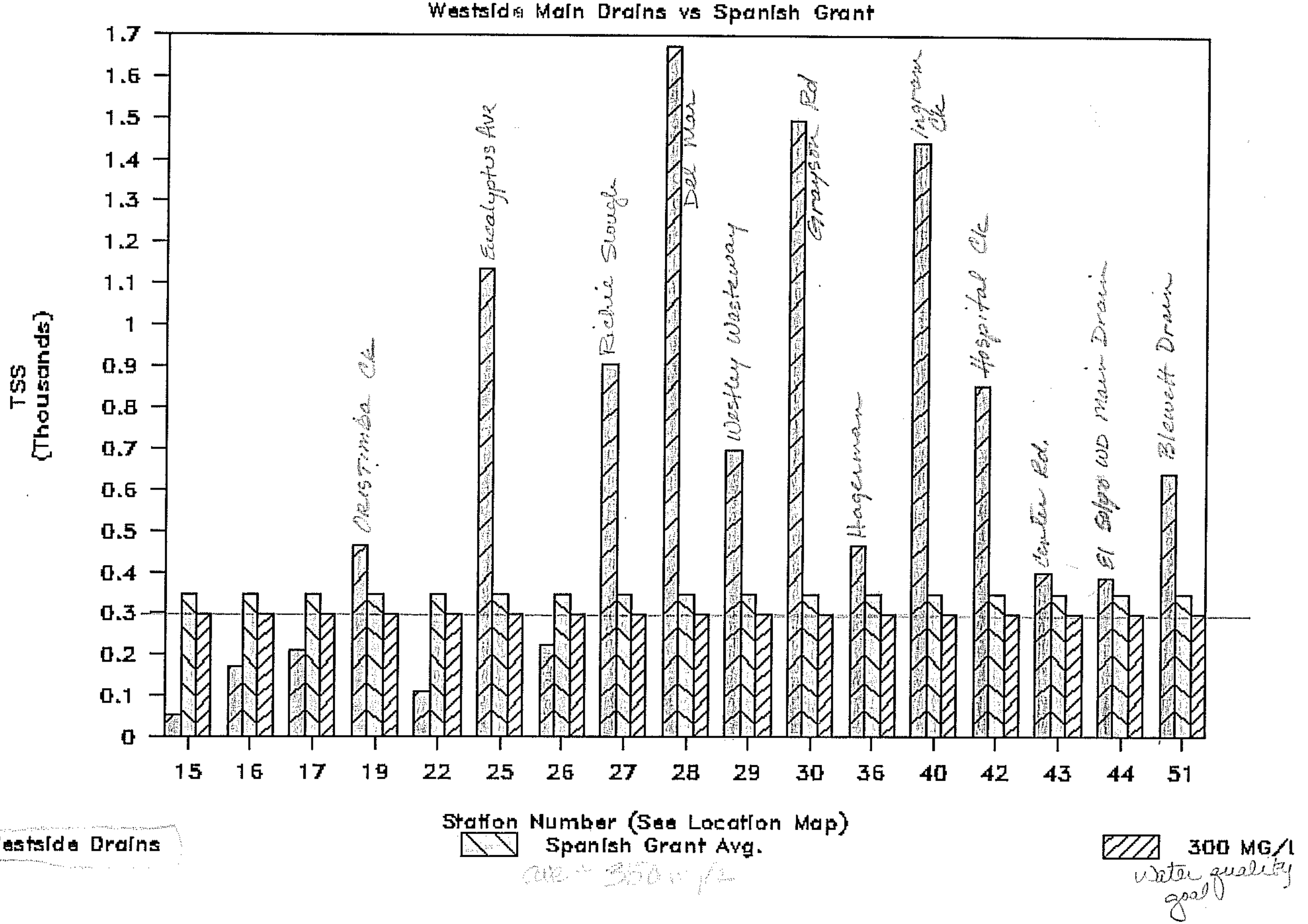


FIGURE 9 AVERAGE WEEKLY TSS



in estimating tonnage of sediment. For example, the flows and TSS were assumed to be constant for the 24 hour period and that the 24 hour period was representative of the weekly variation in sediment yield. This is considered somewhat valid since many West-side crops are irrigated on a 7 to 14 day schedule. Even with 30 minute readings of TSS and flow there is significant variation that can occur (see Appendix B).

Since the preliminary data show high variability in both flow and sediment readings it is recommended that the following factors be considered in any future studies:

1. Development of a more detailed water quality monitoring program including baseline and background measurements, measurements to show incremental improvement in water quality due to any adopted programs, and on-farm evaluations of the effectiveness of Bmps or other adopted management practices for key pollutants.

2. Develop a rating system to categorize the identified basin as subject to slight, moderate, or severe erosion from irrigation water. Delineate more precisely those areas within the identified drainage basins that are major sediment contributors. Review the hydrological unit focused on by this study and suggest any needed changes for future work.

3. Recognize the importance of natural events such as severe storms in the production of sediment yield, and attempt to account for any sediment generated from rangeland upslope of the current study area that may contribute to sediment loading of the San Joaquin River.

4. Establishment of either numerical or qualitative water quality goals for high priority NPSP variables.

CHAPTER VI

ROLE OF BEST MANAGEMENT PRACTICES

It is felt that substantial achievements can be made in the control of non-point source pollutants from agricultural lands by the use of Best Management Practices (BMPs). This is because, when implemented in a systematic fashion, these practices can have a significant impact on the NPSP problem facing individual farmers and society as a whole. Best Management Practices control sediments, nutrients and other pollutants in surface return flows by: 1) eliminating or reducing surface irrigation return flow; 2) reducing or eliminating soil erosion so that there is little or no sediment in surface runoff from irrigation; and 3) removing sediment and associated materials from surface runoff before these waters can impact offsite beneficial uses. Each BMP implemented in the Spanish Grant State Assistance Project (SAP) functioned to reduce the NPSP problem. Surface return flows were decreased by implementation of irrigation water management, reduced length of runs and gated surface pipe. Soil erosion was decreased through land-levelling and shortened irrigation runs coupled with reduced stream sizes. Sediment in surface return flows were removed by the construction of debris basins. These and a variety of other practices and management methods singularly or in combination have proven ability to dramatically reduce sediment loading to the San Joaquin River. Table 13 shows four categories of Best Management Practices and their effect on tailwater volume and quality.

Many options are available to farmers wishing to reduce their irrigation return flows. BMPs can be tailored to fit each farmer's specific situation with management, vegetative and structural alternatives available. Table 14 describes the general characteristics of each category of practices.

Experience in the Spanish Grant (SAP) has shown us that these practices not only reduce non-point source pollutants, but in many instances lower production costs and increase crop yields.

TABLE 13 BEST MANAGEMENT PRACTICES AND THEIR EFFECT ON TAILWATER VOLUME AND SUSPENDED SEDIMENT LEVELS

Practices by Category	Practice Effect: Tailwater Volume	Practice Effect: Tailwater Quality
Cultural and Land Management BMPs		
Irrigation Evaluation	N	N
Irrigation Water Management	L-H*	L-H*
Conservation Cropping Sequence	L-H*	L-H*
Shortened Irrigation Runs	L-M*	L-M*
Irrigation Land Levelling	L-M*	L-M*
Irrigate Alternate Furrows	L-M*	L-M*
Closed Border Irrigation	H	H
Border Strip, Non-tillage	L-H*	H*
Tailwater Reuse Downslope	L-H*	L-H*
Vegetative Management BMPs		
Grassed Drainage Ditch	L	L-H*
Filter Strip-Vegetative	L-H*	M-H*
Cover Crop	L	L-H*
Structural BMPs		
Irrigation & Drainage Pipelines	L-M*	L-M*
Gated Surface Pipe	L-H*	L-H*
Automated Surge Irrigation System	M-H*	M-H*
Solid-Set Sprinkler	H*	H*
Drip Irrigation System	H	H
Micro Spray Irrigation System	H	H
Sediment Retention BMPs		
Debris Basin with Outlet	L	L-H*
Debris Basin, Tailwater Recovery	H	H

H-High, M-Medium, L-Low, N-Not significant

*-Effectiveness depends upon degree of treatment

TABLE 14 General characteristics of categories of practices. USDA Soil Conservation Service "Water Quality Field Guide, September 1983"

Characteristic	Practice Category		
	Management	Vegetative	Structural
Flexibility to change	High	High	Low
Level of change required in farming system	Low	Low to High	Low to High
Cost			
Initial	Low	Low	Moderate to high
Operation & maintenance	Low	Low	Low
Income Effects	Positive to negative	Positive to very negative	Usually positive

Chapter VII

Planning for Implementation

Rationale for Detailed Analysis of the West-side

The following discussion is intended to recognize existing limitations, highlight the complexity of NPSP problems and emphasize some important questions that should be addressed in the next phase of analysis.

Irrigated agricultural lands in the West-side of Stanislaus county were chosen to be analyzed further based on: (1) earlier studies that identified the area as the single most important and consistent contributor of NPSP pollutants within the San Joaquin River Basin area upstream of the Delta [13] and (2) previous water quality work experience in the area gained through the implementation of a joint RCD/SCS/SWQCB pilot project to install selected BMPs. The pilot project also monitored and evaluated specific practices for their NPSP abatement effectiveness. The pilot project experience demonstrated that well implemented BMPs can be very effective, to varying degrees, in reducing NPSP loadings from irrigated lands (A more detailed treatment of the Spanish Grant and Crow Creek pilot project's results are summarized in the final report submitted to the SWQCB by the RCD and Patterson field office of the SCS, dated December 1987).

The West-side has been recognized as a consistent NPSP source area due to the combined effects of: (a) the area's physical geography and location immediately adjacent to the river; (b) it's extensively altered system of surface and subsurface hydrology; (c) it's soils that are derived from coastal range parent material which yields finer textured and more fertile soils than are generally found on the east side; and consequently (d) more intensive land use patterns adjacent to the river relative to other areas in the basin (115,000 acres of moderate to high-valued irrigated agriculture lie between the San Joaquin River and interstate highway 5). The area directly impacts San Joaquin River beneficial uses and the Sacramento/San Joaquin Delta.

The entire West-side of the county consists of approximately 399,000 acres with three predominant agricultural land uses; rangeland, irrigated cropland and irrigated orchards and over 1500 land-use units. Rangeland and native vegetation represent roughly 66% (265,000 acres), irrigated cropland 29% (115,000 acres), and irrigated orchards currently approximate 4% (14,500 acres) of the total area (See Table 15). Of the 115,000 acres of irrigated cropland 78,000 acres lie between the San Joaquin River and the Delta-Mendota canal and 37,000 acres are located between the Delta-Mendota canal and the California aqueduct. Urban and industrial land-uses occupy only one percent (4,500 acres).

Table 15 Land-use Comparison of the 1979 Spanish Grant Study and the Entire West-side

Land-use	Spanish Grant Study Area	West-side Area
Irrigated Crops	81%	33%
Rangeland and Native Vegetation	16%	66%
Urban & Other	3%	1%
Total	100% of 6,960 Acres	100% of 399,000 Acres

Rangeland is mostly confined to the extreme western side of the county, west of interstate number 5 and is thought to be a significant contributor of sediment to intermittent tributaries of the San Joaquin River. This assumption is based on a previous study by the SCS titled "The Spanish Grant Drainage District and Crow Creek Pilot Study". The study analyzed erosion, sediment delivery and yield to streams in an area which approximately makes up 2% (6960 acres) of the entire West-side. The Spanish Grant study area is representative of the entire West-side with respect to land-use categories, but it is not generally representative of the entire West-side in terms of percent area occupied by land-use category. Irrigated agricultural lands constituted over 80% of the land area. Rangeland occupied only about 16% of the Spanish Grant study area.

Rangeland throughout the western side of the county is not considered a significant supplier of other NPSP pollutants and it's sediment yield into the San Joaquin River is currently believed to predominantly occur during infrequent but intensive storm events which move accumulated coarse textured deposits further down the hydrologic system. Most fine soil particles from rangeland probably move through the system with annual runoff. This needs to be further studied.

The 1979 Spanish Grant Pilot study indicated that the highest erosion rates, 4.2 - 7.3 tons/acre/year were found on the irrigated cropland and orchards. However, the greatest sediment yield was from sheet and rill erosion and gully erosion on rangeland (24 and 33 percent respectively or 57% of the total) even though rangeland only made-up 16% of the study area. Sediment yield from irrigated cropland and orchards was estimated to make-up 33 percent. Streambanks accounted for the remaining 10 percent. The difference between erosion rates and sediment yields is attributable to the sediment delivery ratios estimated for each land use/resource situation.

It should be noted that the Spanish Grant and Crow Creek study area also is not generally representative of the entire West-side due to the fact that on-farm sediment basins are required by the Spanish Grant Drainage District and have been mandatory since 1973. Therefore, sediment delivery ratios and the predicted yields from irrigated agriculture to the San Joaquin River in this area should be significantly lower than that expected in the remainder of the irrigated agriculture area which makes-up the majority.

The 1979 report evaluated irrigation-induced erosion, sediment delivery and sediment yield to streams based upon on-farm sampling of fields with sumps (sediment or debris basins) that had trapping efficiencies ranging from 44 to 95%. The average sediment trap efficiency used for extrapolation of sampled results for the entire study area was 77 percent. Sediment delivery ratios and yield from irrigated cropland (the dominant irrigated land use on the West-side) without sumps or with poorly maintained sumps with much lower efficiencies is significantly higher.

The study also indicated that sediment deliveries from the respective sources have a somewhat continuous distribution for nine months of the year. Sediment yield from the rangeland occurs during the winter rains (December-February). The predominant sediment yield, as well as the yield of many other NPSP pollutants, from irrigated lands occurs during the irrigation season (March-August) with a peak NPSP delivery to the San Joaquin River during the month of July coinciding with peak irrigation runoff and lowest stream flows.

Planning Considerations

The above discussion was presented to explain, in part, how irrigated agriculture of the West-side became the current focus of this report and the anticipated focus of a subsequent analysis of greater detail. The background information and displayed rationale are also intended to serve as an introduction to the following treatment of the natural resource planning process and recommendations for future work.

Natural resource planning for decision making is a complex and dynamic process. It is often a process analogous to dissection whereby the constituent parts of the whole are separated and analyzed to better understand their individual functions. In natural resource planning, the individual components are then placed back within the context of the whole system to gain as clear an understanding, as necessary, of the physical and biological relationships at work.

Problem definition as well as determining the scope and detail of analysis needed is the most critical part of natural resource planning. Determining the level of effort needed goes along with the initial assessment of existing conditions and trends and the magnitude of related problems. The main objective of this initial scoping process is to begin definition of the situation and scale the subsequent level of analysis effort to a degree commensurate with the expected benefits from intervention. Intervention is here used to mean a change in the future situation as a direct result of some action being taken, e.g., a project, policy changes, an information campaign, etc.

However, it should be noted that intervention is not the objective of planning. Any initial analysis effort is based upon some condition that needs attention. Effective planning should help local decision makers to: (a) determine the nature of their problem; (b) decide whether the problem is likely to continue, worsen or diminish; (c) explain whether or not the problem is sufficiently damaging so as to call for some type of intervention; and (d) indicate which of the possible alternative means of intervening would most likely produce desirable results at a justifiable cost.

Any analysis presupposes that conclusions can be made and that technically, economically and socially acceptable alternatives will be sought which either reduce the size of the problem, solve it or mitigate negative effects by developing positive effects elsewhere. Although not common, the most desirable alternative in some situations could be acceptance of the existing condition given current technological capabilities and social values. In addition, the nature of human/environmental interactions often presents a major obstacle to achieving improvements through planning based on technical analysis and local decision making. Natural resource systems and human uses of them are often found to have very complex and interactive relationships. Although human understanding and ability to evaluate natural resource/land-use interactions has made tremendous progress and continues to improve, there remain significant information needs, gaps in our understanding and technological limits to treat natural resource problems.

For example, the irrigated agriculture focus of this report has a well founded basis as portrayed above, but there remain serious questions as to whether or not the damage caused by NPSP from irrigated lands is more significant than damages caused by NPSP loadings from rangeland within the same watershed or other sources such as geologic erosion and chemical loadings from nature. Likewise a serious information gap presently exists as to whether or not partial or even a complete clean-up of the entire watershed would result in significant measurable and economically justifiable improvements in the quality of San Joaquin River waters. Loadings from other sources upstream of the study area could render clean-up efforts within the study area ineffective.

To attempt to answer this last question, the impaired beneficial uses resulting from NPSP loadings within and offsite of the West-side must be identified, evaluated and linked to the sources that cause the damages. If sediment is the main problem and rangeland is identified as the main source then the logical focus of future implementation efforts should be directed accordingly. If damage from agricultural chemicals is the main problem then the irrigated agriculture lands would be the appropriate focus. If upstream or other sources are found to be more important than previously believed, then the relevant focus would be on whether or not NPSP reductions within the study area would still contribute significantly to stated water quality objectives or move towards achievement of a "critical mass" level of reductions.

The idea of critical mass is here intended to relate problem complexity and importance with necessary and sufficient levels of effort to result in desired change, e.g., toxic NPSP loadings from a given area could present a sufficient human health hazard to warrant clean-up efforts even when other sources are as important or more important; even when economic justification can not be found, etc., because economic value can not be placed on human lives.

These questions currently exist and may or may not be completely resolved during the expected next phase of analysis depending on the complexity of the problem. The next phase will move towards answering, if not answer, such concerns and determining what possible interventions in the irrigated agriculture areas could achieve in view of other NPSP sources and the commingling of pollutants that currently occurs and also affects the San Joaquin River system. To the extent practical, the next phase should also determine at what point significant improvements to San Joaquin River water quality could be expected from land treatment in the West-side area and would such efforts be worth their costs, i.e., can one or more interventions with positive benefit/cost ratios be found. If not, then cost effectiveness analysis could be employed to analyze the least costly alternative to achieve a given level of NPSP loading reductions.

Benefit/cost analysis entails at a minimum the development of two future scenarios: (1) future NPSP loadings and water quality without some type of intervention in the West-side, i.e., what current conditions and trends relative to the impaired beneficial uses are likely to continue; and (2) what would be the expected future with some type of intervention. The difference between these two visions of the future must be determined in order to ascertain expected change, and in particular, expected benefits attributable to the intervention. Understanding the impacts of contemplated policies and or programs and projects before implementation is the main goal of pre-project planning.

Specifically, the next phase of analysis should begin with an interdisciplinary team reconnaissance of the entire watershed to identify and estimate sources and rates of erosion, sedimentation and the loading of selected other NPSP pollutants of main concern. A survey of impaired beneficial uses both onsite and downstream should also be made with quantified estimates to the extent practical. The recommended effort would build upon the existing knowledge/experience base regarding irrigated agriculture and proven BMP technologies and consider other sources as well.

Much is already known about NPSP movement within and off of the irrigated agricultural land area and regarding the efficacy of BMPs to reduce or control NPSP. The broader issues raised above also deserve more attention. It is noteworthy that even if the broader questions are not answered after the contemplated next step in planning, invariably information will be generated which contributes to greater understanding of the physical and biological causality and this area's impact on the broader issues. Completion of the next phase should lead to, if not determine whether or not economically justifiable recommendations and actions at one level or another (farm, subwatershed, watershed-wide, etc.) could be made and if not the results will point the way for establishing reasonable NPSP loading reduction goals.

Interdisciplinary/Participative Nature of Planning

In order to effectively evaluate natural resource/land-use condition, problems and trends an interdisciplinary team of specialists in close consultation with local decision makers, landusers and other interested parties is needed. An interdisciplinary team is essential in order to assess what is going on with respect to the seven main variables analyzed in natural resource inventories and environmental planning: (1) land use; (2) soils; (3) rainfall; (4) topography; (5) vegetative cover; (6) streams and man-altered hydrologic characteristics; and (7) transportation infrastructure (erosion, sedimentation and the hydrology altering effects of associated roads, highways, and railroad lines). All of these variables represent focal points requiring different analytical training and skills to be able to define the resource problems and understand a given hydrological unit's land-use/resource interactions.

The planning process essentially involves all concerned in an interactive, repetitive dialogue which generates information and understanding with an increasing degree of detail over time that leads to decision making. This process is especially important in natural resource planning in general and specifically within an area such as the West-side Stanislaus County due to the complex and dynamic nature of NPSP and the large number of landusers involved (over 1500). Any successful effort to reduce NPSP loadings must also employ inter-agency communication and public participation. Inter-agency coordination is desirable to draw upon the different expertise and perspectives of existing local, state and federal agencies in the area. Coordination among agencies is also desirable to achieve complementarity of efforts. Any possible special funding should be coordinated with other existing fund sources such as the Agricultural Conservation Program (ACP) dollars through the ASCS of the USDA.

Public involvement is crucial for the success of any analysis effort and prepares the way for possible project or other intervention in the future. This point deserves additional attention. The San Joaquin River is the principal receiving body of water. The irrigated agricultural lands adjacent to the river are presumed, at this time, to be most critical to San Joaquin River water quality. Given this situation, priorities for implementation of future RCD/SCS work with or without special funding for implementation will be further defined after the next step in planning (natural resource inventory and problem definition).

The planning for implementation process as a whole and ideally may be summarized as follows:

- Preliminary review/investigation of a resource concern;

- Natural resource inventory and problem definition (initial formulation of at least one viable alternative);

- Setting planning goals and objectives;

- More detailed investigation and formulation of alternative plans;

- Selection of the recommended plan(s);

- Acquisition of funding;

- Establish before implementation data collection needs and mechanisms;

- Guide and monitor implementation;

- Collect after project data to measure actual results;

- Evaluate results;

- Make recommendations for future efforts, if any, and share lessons learned with decision makers and those implementing other efforts;

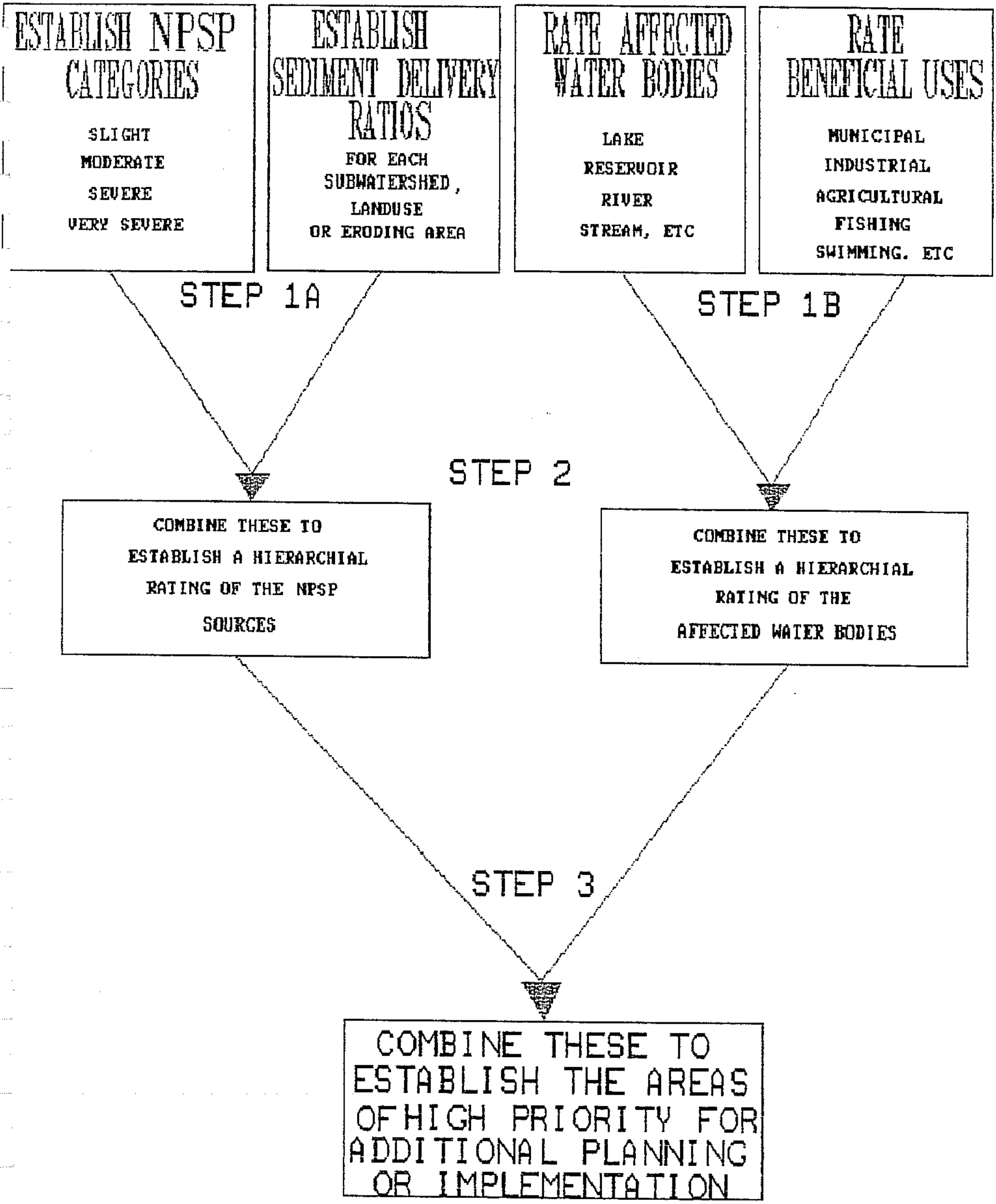
Keeping the public informed and involving them in the planning process via steering committees, public meetings, interviews, newsletters, etc. is of great importance for establishing priorities. Priorities should be established to target those areas, land-uses and BMPs that will yield the best NPSP abatement results. Within areas defined to be critical to water quality a certain number of landusers will be present. Given limited funds for implementation, it may be considered desirable to identify high priority farms. High priority status would mean that they would be the first to receive funds after water quality plans are approved. Low priority farms would be funded as available, if possible and would otherwise have to rely on ACP monies or other sources for implementing recommended BMPs. Figure 10 depicts the iterative planning process for establishing priorities.

Regulatory vs. Voluntary Program Approaches

NPSP planning and project implementation experience to date suggests that the complex, diffused nature of NPSP and further complicating effects from commingled pollutants from both within a given study area and from other sources, implies that no single unambiguously superior policy or program approach or mix of policies can be considered the best approach before detailed analysis has been conducted. However, the same experience suggests that the complex nature of NPSP generally renders all but predominantly voluntary programs extremely costly, if not un-implementable.

Regulatory type approaches work best when direct responsibility can be assigned to a small number of

FIGURE 10 A METHOD FOR DETERMINING PRIORITY AREAS *



* Adapted from "Recommended Plan of Best Management Practices for reduction of Agricultural Sediment", USDA/SCS/CA River Basin Planning Staff, June 1979.

individuals and or groups for specific actions contrary to acceptable behavior. The West-side appears to not meet such criteria for a regulatory approach to be successful. Irrigation applications on the West-side occur at different times on many different soils and crops, which are treated with different fertilizers and pesticides with distinct active ingredients, that persist for varied lengths of time and whose decay functions are often very dependent upon changing environmental conditions. Furthermore, with common and commingled outlets for surface and subsurface drainage the viability of a wholly regulatory approach is especially doubtful, i.e., assignment of direct responsibility for one action or another as with point sources is extremely difficult to document and prove.

In summary, wholly regulatory approaches, under circumstances as described above, tend to require masses of detailed information not currently available, have high monitoring and enforcement costs, including litigation costs and are therefore generally difficult to administer and are generally less effective. Programs/policies relying on voluntary participation, but also involving a mixture of economic and legal incentives/disincentives appear to be preferable. Regulatory disincentives become the method of last resort to deal with those few individuals that occasionally misapply substances or conduct practices that disproportionately contribute to NPSP loadings.

Voluntary participation approaches combined with economic incentives to participate are viewed by growers and the general public as more socially acceptable (see Appendix A for additional information regarding private economic incentives to achieve public objectives). When combined with economic analysis, voluntary programs can establish reasonable estimates of achievable and justifiable NPSP abatement goals. Coupled with implementation oversight, such efforts can adapt to unforeseen changes to adjust cost/share rates to gain wider participation, adjust targeted areas or land-uses, favor some BMPs over others as land use changes, etc.

The West-side is a natural focus of NPSP debate which might tend toward regulatory approaches given continued rapid population growth in the state and demands for improved San Joaquin River water quality. Patterson also is experiencing rapid population growth and urbanization. It was one of the ten fastest growing cities in the state with under 50,000 residents during 1987. The rural population as a whole is expected to continue a relative decline in numbers as urban expansion continues. These parallel trends, population growth and increased urbanization, will continue to increase competition with agriculture for land and water. It is therefore in the interest of the agricultural sector to find ways to avoid regulation such as voluntary adoption of BMPs and self-regulation if necessary in order to maximize self determination. Competent natural resource planning can effectively provide agricultural interests and public policy makers with information and the means to achieve common goals and minimize rural/urban conflicts.

Planning for Implementation Recommendations

- An interdisciplinary team of specialists should conduct the next phase of planning to (a) more clearly define the water quality problems associated with NPSP from the Westside; (b) trace key water quality impairing pollutants to their sources; and (c) identify all damage categories and estimate dollar values resulting from the impairment of beneficial uses for those that are economically quantifiable.

- A 6-8 week level of effort (3-5 weeks of field data collection and 2-5 weeks of report preparation) is recommended in order to make a preliminary determination whether or not a justifiable investment of local, state or federal funds could be made for the design and implementation of a NPSP abatement project (Differences between various funding sources could arise mainly due to differing priorities, funding levels and number of claimants, timetables for implementation, etc., necessitating consideration of the different options available). If an economically justifiable alternative can not be identified, then cost effectiveness analysis could be pursued to achieve a given level of NPSP abatement.

CHAPTER VIII

INSTITUTIONAL MECHANISMS FOR IMPLEMENTATION

Within the study area many agencies exist at the Federal, State, City, County and Special District level with authority to work on water quality issues. In the study area NPSP has been and continues to be dealt with at all these levels. Studies conducted in the San Joaquin Basin recommend a cooperative effort among agencies and farm organizations based on a voluntary framework to achieve water quality objectives.

The Resource Management Subsystem, i.e. BMP approach has been articulated in SCS studies as the most effective means to deal with NPSP at the farm level. Getting farmers to adopt BMPs on a larger scale in the study area, will require those agencies with authority and expertise in the NPSP field to pool resources and work closely together.

With the introduction of irrigation water to West-side farms came the need for surface and subsurface drainage to collect and dispose of irrigation tailwaters. In the study area several large drainage networks were constructed in the early '60s. These networks collect surface and subsurface water from area farms and discharge into the San Joaquin River. Since their inception these surface drains have been plagued with sedimentation problems. In 1973 the Stanislaus County Board of Supervisors adopted rules and regulations governing desilting drainage sumps in designated storm drainage districts. Appendix C shows the Board's resolution on desilting sump construction, maintenance and monitoring requirements. These desilting sumps have been effective in reducing total suspended solids entering drainage networks when properly sized, constructed and maintained.

In 1988, high sedimentation cleanup costs in their irrigation district canals prompted the directors of the Patterson Irrigation District to require desilting sumps on farms which discharge tailwater into district canals. These sumps will be installed based on the 1973 ordinance. *

While such regulatory actions by the County and Irrigation Districts are sometimes necessary and warranted to effect a cure to a specific problem, it is generally hoped producers in the study area can be convinced to voluntarily take action to reduce offsite impacts. In order for such action to occur the agricultural community must be informed regarding the detrimental impact some of their actions have on beneficial water uses. They must also be given practical, economical and feasible alternatives. While it is readily apparent to anyone working on NPSP that a great deal of information exists on detrimental impacts to San Joaquin River beneficial uses, it may be a mistake to assume that farmers in the study area truly understand the impact his or her on-farm practices have offsite. If such understanding is truly absent among study area farmers it is the responsibility of all agencies involved in NPSP control to disseminate information to these individuals so they may have the opportunity to deal with the problem. Although many governmental agencies and groups are involved in the study area with NPSP education efforts, (e.g. UC Cooperative Extension Service, Soil Conservation Service, RWQCB, etc..) one organization appears uniquely situated to lead the information and education program. This organization is the West Stanislaus Resource Conservation District or RCD.

Comprised of respected local landowners, the district board is especially qualified to lead both the information/education program and one geared towards implementation of BMPs in the study area. Formed under the provisions of the Public Resources Code, Division 9, of the state of California, the West Stanislaus RCD has the responsibility for developing a Soil and Water Conservation program for their district. Since 1980 the RCD, with SCS assistance has been actively assisting landowners reduce soil erosion, sedimentation, conserve water and improve water quality. By dealing with known and respected local leaders most farmers are more comfortable and receptive to information regarding their farming operations.

The RCD has demonstrated considerable expertise in information and educational programs. In the past the district has sponsored seminars for local producers on the NPSP problem, promoted cover crops in orchards, published informational pamphlets, had consultants research and report on water quality and shown considerable success in getting local media to report on resource concerns. Utilization of this institutional mechanism also makes practical sense from the use of existing personnel perspective.

Currently the district is developing two educational tools to raise awareness about erosion and water quality. The first is the district's rainfall/erosion simulator which provides audiences with a graphic display of the factors which result in water erosion and sedimentation. Secondly, the RCD is in the process of developing a quarterly newsletter which will focus on such topics as resource concerns, technology transfer, irrigation practices and water quality.

Beyond having considerable experience in the information and education sphere, the RCD has successfully implemented a comprehensive and complete demonstration of BMPs on agricultural cropland in the county. Starting in 1982 the RCD administered the Spanish Grant Conservation Program. This program involved 50 percent cost-sharing of state assistance funds, approved under the Clean Water and Water Conservation Bond Law of 1978, to landowners who installed BMPs to prevent soil erosion, sedimentation and conserve water. Sixteen individual projects were cost shared, resulting in $758,462 dollars in BMPs being placed on the land from March 1982 to September 1987. If additional funding for NPSP control becomes available, the RCD is the most logical choice to administer such a program with SCS technical assistance.

At present the only cost-share assistance available for installation of BMPs in the study area is through the Agricultural Conservation Program (ACP) of the Agricultural Stabilization and Conservation Service (ASCS). Under this program agricultural producers are eligible to receive a 50% cost share, up to $3,500 in a calendar year, for installation of approved practices. Practices applied in the study area include water conservation measures, i.e. plastic and concrete supply pipelines, mainlines for drip and sprinkler systems, and tailwater return systems. A new practice for 1988 will allow piping of excessively eroding drain ditches along with the construction of a desilting sump based on the 1973 county ordinance. The ACP program has been and continues to be one of the best mechanisms for installing BMPs in the study area. The major drawback of this program has been the relatively low funding levels which are far below producer demand in most years.

In order to effectively administer and implement a comprehensive water quality program on the West-side, the RCD should be provided funding to hire a program manager. This position is considered necessary for the RCD to conduct a large scale cost-share program. The person chosen for this position will need to maintain a close working relationship with the Regional & State Board, various agencies, especially the Soil Conservation Service. Hiring a professional manager will help expedite the allocation of cost-sharing funds to local landowners ready to install and maintain proven BMPs approved by the Soil Conservation Service. Y

Implementation of BMPs does not need to occur over the entire study area for water quality improvement. A steering committee of local leaders and concerned agencies should be established to further identify problem areas, prioritize needed BMPs and lead a public participation program. The RCD along with the SCS could work with land users to develop plans, arrange schedules, provide technical assistance and obtain funding for BMPs where appropriate. The steering committee could in certain cases recommend voluntary or self regulation to avoid, if possible, regulatory action.

3 drains
≈50%?

Finally, such an approach seems appropriate as it allows the most interested individuals to guide their future through sound resource planning.

CHAPTER IX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Patterson Field Office of the SCS was contracted by the California Water Resources Control Board to study non-point source pollution entering the San Joaquin River via drainage outlets from the West-side of Stanislaus County. The objectives of the study were to:

1. Identify the major agricultural drains on the West-side;

2. Estimate the magnitude and frequency of excess irrigation water discharge into the drains;

3. Identify and estimate the impacts of farming operations on sediment loads;

4. Identify "Best Management Practices" that can reduce runoff and suspended sediment in irrigation tailwater;

5. Develop costs for implementing different levels of farm drainage flow reduction; and

6. Assess methods to increase grower awareness of the need for conservation practices.

The West-side has been recognized as a consistent NPSP source area due to the combined effects of: (a) the area's physical geography and location immediately adjacent to the river; (b) it's extensively altered system of surface and subsurface hydrology; (c) it's soils that are derived from coastal-range parent material which yields finer textured and more fertile and erosive soils than are generally found on the east side; and consequently (d) more intensive land use patterns adjacent to the river relative to other areas in the basin (115,000 acres of intensively managed and relatively high-valued irrigated agriculture lie between the San Joaquin River and Interstate highway 5). The area is also considered important due to the state-wide importance of the main impaired water body that the San Joaquin River affects - the Sacramento/San Joaquin Delta and water transfers for high-valued uses in the south of the state.

The entire west-side of the county consists of approximately 399,000 acres with three predominant agricultural land uses; rangeland, irrigated cropland and irrigated orchards and over 1500 land-use units. Rangeland and native vegetation represent roughly 66% (265,000 acres), irrigated cropland 29% (115,000 acres), and irrigated orchards currently approximate 4% (14,500 acres) of the total area. Of the 115,000 acres of irrigated cropland 78,000 acres lie between the San Joaquin River and the Delta-Mendota canal and 37,000 acres are located between the Delta-Mendota canal and the California aqueduct. Urban, military and industrial land-uses occupy only one percent (4,500 acres).

Rangeland is mostly confined to the extreme western side of the county, west of interstate number 5 and is presumed to be a significant contributor of sediment to intermittent tributaries of the San Joaquin River. This assumption is based on a previous study by the SCS titled "The Spanish Grant Drainage District and Crow Creek Pilot Study". The study analyzed erosion, sediment delivery and yield to streams in an area which approximately makes up 2% (6960 acres) of the entire west-side. The Spanish Grant study area is representative of the entire west-side with respect to land-use categories, but it is not generally representative of the entire west-side in terms of percent area occupied by land-use category. Irrigated agricultural lands constituted over 80% of the land area. Rangeland occupied only about 16% of the Spanish Grant study area.

Rangeland throughout the western side of the county is not considered a significant supplier of other NPSP pollutants and it's sediment yield into the San Joaquin River is currently believed to predominantly occur during infrequent but intensive storm events which move accumulated coarse textured deposits further down the hydrologic system. Most fine soil particles probably move through the system with annual runoff. This needs to be further studied.

Sampling of West-side drains conducted for this study indicates that variation in flow rates, Total Suspended Solids (TSS) and sediment content is very marked from one drain to the next and during the year. Greatest concentration of TSS occurs during the peak period of the irrigation season (July-August) with recorded samples as high as 7800 mg/l from one drain and estimated sediment loads as large as 140 tons/24 hrs from another. However, three drains were found to produce 51 percent of the total estimated flow and 50 percent of the 24 hour estimated sediment yield.

A joint RCD/SCS/SWQCB pilot project to install selected Best Management Practices (BMPs) was implemented during the mid-1980's. The pilot project also monitored and evaluated specific practices for their NPSP abatement effectiveness. The pilot project experience demonstrated that well implemented BMPs can be very effective in reducing NPSP loadings from irrigated lands. Surface water sediment reductions attributable to the Bmps ranges from 20% - 90%. Costs of BMP implementation range from $5/acre/year to $500/acre/year. The identified Bmps include, but are not limited to:

- Irrigation Evaluation;

- Irrigation Water Management;
- Conservation Cropping Sequence;
- Irrigation Land Leveling;
- Irrigate Alternate Furrows;
- Closed-Border Irrigation;
- Border-Strips, Non-tilled;
- Tailwater Reuse Downslope;
- Grassed Drainage Ditches;
- Vegetative Filter-Strips;
- Cover Crops;
- Irrigation and Drainage Pipelines;
- Gated-Surface Pipe;
- Automated Surge Irrigation Systems;
- Solid-Set Irrigation Systems;
- Drip Irrigation Systems;
- Micro-Spray Irrigation Systems;
- Debris Basins with Outlets; and
- Debris Basins with Tailwater Recovery Systems;

A more detailed treatment of the Spanish Grant and Crow Creek pilot project's results are summarized in the final report submitted to the SWQCB by the RCD and Patterson field office of the SCS, dated December 1987.

In summary, all work to date indicates that the area is a significant contributor of NPSP pollutants and that Best Management Practices, either singularly or in combination, can be very effective for reducing NPSP loadings being delivered from the area into the San Joaquin River.

The work performed in the area thus far, for understandable reasons, has sometimes been focused on special concerns and localized areas of the west-side without fully linking on-farm resource management with the broader issues related to offsite damages, hydrological boundaries and all sources of NPSP on the West-side, e.g., groundwater, rangeland, unmanaged native vegetation areas, highways where significant quantities of chemical herbicides are often used, etc. Therefore, it is recommended that:

1. An interdisciplinary team of specialists conduct a comprehensive rapid reconnaissance of the entire West-side in close consultation with the West Stanislaus Resource Conservation District, local interests and the RWQCB to (a) more clearly link the water quality problems associated with NPSP from the west-side with the key water quality impairing pollutants and their sources; (b) identify important damage categories and estimate dollar values resulting from the impairment of beneficial uses for those that are economically quantifiable; (c) estimate treatment costs; and (d) recommend implementation alternatives.

can you define resource values

change to assessment of on-farm economics

2. A 6-8 week level of effort (3-5 weeks of field data collection and 2-5 weeks of report preparation) is recommended in order to make a preliminary determination whether or not a justifiable investment of local, state or federal funds could be made for the design and implementation of a NPSP abatement project to treat identified high priority problems. Justification could be based on benefit/cost analysis that identifies an economically justifiable alternative or upon compelling environmental concerns that benefit/cost analysis can not always capture. An economically justifiable alternative would imply that implementation could then be pursued with a specific funding source in mind.

3. If results from the next phase of analysis indicate that economic justification is not found, (but environmental degradation linked to the study area provides policy-makers with sufficient rationale for moving forward with some type of intervention,) then cost effectiveness analysis should be made targeted to the achievement of given levels of NPSP abatement at lowest cost. This approach, if chosen, could provide decision-makers with implementable plans for several, quantifiable levels of key pollutant reductions with their respective planning and treatment costs.

4. Should any special project be determined as necessary, it is logical and therefore preferable that an existing local institutional mechanism, such as the West Stanislaus RCD be chosen as the leader for planning and implementation with direct technical assistance and guidance from our agency, the Soil Conservation Service. The West Stanislaus RCD would best be able to coordinate locally with the numerous irrigation and drainage districts and serve as liaison with area farmers and other interested parties through public participation efforts. Should this come to fruition, then a full time RCD project administrator/manager should be built within the project design for the duration of the project to provide continuity and daily direction.

5. Any special intervention that might develop should include a more detailed water quality monitoring program within the project area to measure before and after project conditions and specific BMP/resource interactions in order to monitor progress and assess results. Such a program might also be linked with efforts to develop a soil loss nomograph detailing irrigation-induced erosion calculation methodologies especially adapted for the West-side area.

Is this going on in some form now since debris basins authorized in 1988 (pg. 60)? Patterson Irrigation District.

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Appendix A

Economic Information and Planning

The purpose of this appendix is to provide some additional information on economics and planning for NPSP abatement. Two specific objectives are the intended outcomes: (1) a general conceptual framework for the roles economics can and should play in natural resource planning will be presented; and (2) a brief array of the information currently known regarding the economic dimension of selected BMPs, applicable to the Westside of Stanislaus county, will be presented. The second objective should summarize present knowledge and rank order the BMPs by average annual cost and NPSP reduction effectiveness in general.

Economic Analysis and Planning

The purpose of the economic dimension of planning is fundamentally to answer the following simplified questions: (a) Is there an economically justifiable alternative to the present condition? (b) If the answer to (a) is yes, then can or will the neccessary change be achieved without public financial assistance? If not, then is there a need for some sort of public works or publicly funded compensation of private citizens to achieve certain public objectives and if yes, then how much and for which items? and (c) If there isn't an economically justifiable option, which alternative will achieve a given water quality objective at least cost? Of course many related questions must also be addressed during the planning process. For example, there may be more than one justifiable alternative, with one or more being better than the rest. In addition, given limited resources to solve problems, priorities have to be established. etc.

Economics can play a very important role in addressing these planning concerns taking in to consideration both the farmer and public perspectives. The two perspectives are complementary because any successful policy, program or project should serve societal objectives, at as low a cost as possible. To do this, changes in private, farm level decision-making and operations must be made. Without an understanding of farm level decision-making about BMP adoption or rejection, the public objectives can't be attained in an efficient and socially acceptable manner.

Farmers, like most business persons are interested in maximizing profits. To do this farmers in general attempt to minimize costs and maximize returns. Product prices, input costs and operational expenses are the variables they monitor to guide their decisions. All ascertainable and relevant benefits and costs of production will be included in their decision calculations only to the extent that the farmers enjoy all benefits and/or bears all costs of production. Unfortunately, the nature of NPSP from agricultural lands usually means that other individuals located down-slope have to bear the societal costs of production which the farmer generally does not have to deal with. In other words, others unrelated to the farm enterprise, have to deal with part of the consequences (costs usually) associated with farming practices.

If collective action can result in a more equitable and efficient outcome where the costs to society as a whole are lower than the total benefits (damage reductions or cost savings, plus net farmer income, etc.) then action is clearly justifiable. Stated differently, for various reasons private market forces alone are not functioning completely to reflect all costs and benefits to farm in ways that result in excessive NPSP loadings. This suggests a role for government and underlies the justification for the existence of agencies such as our own. Private organizations, markets and government are simply alternative forms of social organization. Government activities obviously should be complementary to the former and special interventions should only be undertaken when there is a clear rationale.

When public intervention is clearly advantageous, implementation efforts should target those changes in private behavior which support public interests at minimum cost. This approach has been termed the public use of private interests and is considered the most efficient and preferred way to achieve societal objectives in a non-conflictive manner. In essence, successful intervention brokers a mutually satisfactory compromise where excessive conflict of interests and competing resource usage previously existed.

The public use of private interests in planning for water quality improvements directly addresses the fact that private economic incentives to achieve conservation and NPSP objectives are usually weak, i.e., it is often less costly to erode, dump drain and surface waters, than to not do these things. Especially when irrigation water is very inexpensive as in the Westside area. This situation provides a reason for exploring justifiable compensatory mechanisms, such as cost sharing, tax incentives, and regulatory disincentives to achieve mutually agreed upon goals. Specifically, the reduction of NPSP from upstream sources as a result of cost shared BMPs on the Westside may be less expensive than removing and/or neutralizing the pollutants downstream via water treatment facilities, the dredging of canals, etc.

In order to deal in practical terms with the theoretical issues mentioned above, an interdisciplinary team of technical specialists (hydrologists, geologists, BMP land treatment experts, etc.) along with economists have to define the resource situation on the Westside and assess the magnitude of present damages resulting from NPSP loadings to the San Joaquin River. Assuming that a reasonable degree of understanding can be made of the present situation, current trends must be evaluated to project their probable impact on the present condition.

This allows the team of specialists to define the area's future without any special project or other intervention. The future with some sort of intervention is then developed. Alternative treatments are evaluated for their technical effectiveness and economic implications. The future without project is then compared to the future with project scenario. The difference between the two is the impact of the project. If the net effect is positive overall, then a justifiable project has been found. If the net effect is negative, then cost effectiveness criteria could still be pursued to achieve benefits which are presumed necessary but not sufficient to economically justify intervention due to problem complexity, i.e., movement towards achievement of a critical mass nature could justify intervention to deal with problems with many unknown relationships and results.

Numerous justifiable alternatives could be found each with different total cost and benefit levels, but favorable benefit/cost ratios. Alternatively, several cost-effective alternatives could be found, one for each level of NPSP abatement being analyzed, e.g., 50%, 75%, or 90% reductions. This is where decision makers should provide guidance to establish water quality goals, i.e., choose between the alternative plans to decide what level of NPSP abatement should be targeted given budget constraints and other considerations. It is worth noting here that, in general, the larger the per acre NPSP reduction sought, the greater the cost to achieve this will be.

As stated before, it is crucial that on-site evaluations be made to understand farm level operations before component practices (BMPs) of a resource management subsystem are selected. This is essential during implementation. During planning this presents a special challenge because site specific evaluations of all farming units can not nor should be made. To deal with this, representative situations are evaluated to assess specific BMP technical and economic viability for the typical farm resource/landuse/financial situations. Those practices that can be expected to pay for themselves should be the focus of information campaigns. Those which, on the average, will not pay for themselves naturally become the focus for potential cost sharing.

The Economics of Selected BMPs in Western Stanislaus County

Ten BMPs will be discussed based on previous work in the study area extracted from the technical appendix to "Farming and Water Quality: A Handbook for the Lower San Joaquin River

Basin", November 1983. The average annual costs presented for each BMP have been updated to present values using index numbers of prices paid by farmers for production items, interest, taxes and wage rates reported in "Agricultural Prices", 1985 and "Agricultural Outlook", November, 1988 (1988 index divided by the 1983 index = 162/159 = 1.02 = price adjustment factor). The BMP costs are assumed to be generally representative of farming conditions in the area. This assumption will have to be validated in the next phase of analysis given the date of the original data collection and the varied and site specific nature of agriculture.

This last point deserves additional commentary. The physical/biological effects and resultant economic consequences of soil and water conservation efforts are very site specific due to variation in soils, slope, rainfall, crops, amount of irrigation water applied, management level, etc. In addition, there are many possible combinations of BMPs and the order in which they may be applied. In addition, changes in management are very difficult to assess and yet they could be the most important factors relating to the relative success or failure of a given practice or system of practices. Maintenance can also be critically important to the continued proper performance of some practices. Therefore, the degree to which changes in operations would impact a given farmer's net income is highly variable and also dependent upon each ones fixed and variable cost structures, changing market prices for inputs and products, government programs, etc.

The following information on ten selected BMPs will suffice to summarize, in a general way, existing knowledge. A rationale for setting water quality objectives and developing implementation strategies will also be discussed. The ten BMPs are:

(1) Cover crops;
(2) Permanent solid-set sprinkler irrigation;
(3) Shortened irrigation runs (800' to 600'as an example);
(4) Land leveling;
(5) Tailwater recovery systems;
(6) Non-irrigated pasture improvement (rangeland planting and fertilizing);
(7) Sediment control basins;
(8) Irrigation water management evaluation followed by management changes;
(9) Irrigation scheduling services; and
(10) Drip irrigation systems;

Other BMPs that should be reviewed for evaluating individually and in combination with others include: conservation cropping sequence; grassed drainage ways; border irrigation; gated pipe irrigation; drip and micro sprinkler irrigation systems; modified supply and drain water conveyance systems; tailwater recovery via gravity for use on lower fields; grassed filter strips; etc.

The following table rank orders the ten selected BMPs by average annual cost assuming average to above average management skills:

BMP	Average Annual Cost/Acre
1.Sediment control basin	$5
2.Non-irrigated pasture improvement	$6
3.Tailwater recovery system	$9
4.IWM evaluation*	$10 - $15
5.Irrigation water scheduling	$15
6.Cover crop	$26
7.Land leveling	$32
8.Shortened furrows	$78
9.Sprinkler irrigation system	$300 - $500
10.Drip irrigation system	$300 - $500

The following table rank orders the ten selected BMPs by percent reduction in surface water sediment:

BMP	Reduction in Surface Water Sediment
1. Drip irrigation systems and	90%
2. Sprinkler irrigation systems	90%
3. Sediment control basins	70%
4. Tailwater recovery systems	60%
5. Land leveling	50%
6. Cover crops	40%
7. Non-irrigated pasture improvement	30%
8. IWM evaluations	30%
9. Irrigation water scheduling	20%
10. Shortened furrows	20%

* One time irrigation system evaluation cost

Given that many other NPSP pollutants are attached to soil particles, it is reasonable to assume that significant reductions of these will also occur with the above practices. If sediment delivery is controlled and tailwater recovery systems are also employed, then substantial improvements to surface water quality can be expected. However, groundwater could be impacted negatively. This points out that BMPs alone or in combination can be very effective, but care must be taken to formulate solutions to surface water quality problems that minimize other possible detrimental impacts. It also implies that planning emphasis be made to analyze the potential for widespread use of two of the BMPs above, in combination; sediment basins and tailwater recovery systems. Finally, it is also noteworthy that those BMPs which represent long-term capital improvement investments, and also result in substantial sediment delivery reductions, should be given special attention from the perspective that they would tend to minimize project exposure to future risks associated with unforeseen changes in landuse.

The data presented above regarding costs and effectiveness does not address two related issues of great importance, economic and financial feasibility of BMPs. Fundamentally, growers have to be convinced that a given BMP or combination of BMPs will pay for themselves (economic feasibility question) and improve operations before they will consider adoption. However, being convinced that the benefits of a given practice or combination exceed their costs is not sufficient to assure adoption. The considered change must also fit within the individual firms financial capabilities. In other words, the economic feasibility could be positive, but the grower might be unable to adopt the desired change due to high initial costs and subsequent cashflow limitations.

Of the above practices analyzed in "Farming and Water Quality: A Handbook for the Lower San Joaquin River Basin", November 1983, only two were found to have a negative impact on average annual net income, sprinkler irrigation on walnuts when converting from flood irrigation and sediment control basins. However, sprinkler irrigation on almonds when converting from furrow irrigation was found to have a positive net effect on income. All but two of the above mentioned BMPs, IWM evaluations and irrigation scheduling, were analyzed in the study from a partial budget analysis perspective which focuses only on those items affecting costs and returns which change as adoption is made. These results therefore suggest that the economic feasibility of most of these BMPs is positive. This may or may not still be true today, but the absence of predominant application of these practices on the Westside implies that some other factors have not been accounted for; perhaps the financial feasibility is questionable for some, maybe associated management skills and levels of effort required are more demanding, etc.

which two?

These concerns should be addressed before implementation begins. Once they have been given due consideration, then BMP application can be linked with the high priority areas and landuses. This will allow planners to aggregate expected participation and effectiveness up to the entire target area and estimate total project cost, expected total cost share dollars needed, etc. The expected results will then have associated levels of NPSP reduction and their respective price tags which will facilitate establishment of NPSP abatement goals that are reasonable and achievable.

APPENDIX B

On-Farm Irrigation Tailwater Evaluation

A field evaluation was conducted to assess tailwater resulting from typical on-farm furrow irrigation practices. Members of the Patterson Field Office, USDA, Soil Conservation Service, measured water delivery and discharge from a district cooperator within the Spanish Grant Drainage District.

On-farm measurements made included supply source suspended solids, application and tailwater flow volumes, and suspended solids in irrigation tailwater discharged offsite.

Objectives of the Evaluation

The four evaluation objectives were to determine:

1. Total amount of irrigation induced tailwater produced during the evaluation.
2. Average concentration of sediment in irrigation induced tailwater.
3. Total sediments exported in irrigation induced tailwater.
4. Seasonal tailwater and sediment discharge levels from the trial.

Background

The on-farm evaluation was conducted on 65 acres of row cropland in Western Stanislaus County. Soils in the field are Myers clay and clay loam. These soils have a soil erosivity (k Value) of 0.28, (see table 2 pg. for My4, My6 and My8 mapping units). The field had been levelled and has a slope of one tenth of a percent (0.1%). The crop grown at the time of the evaluation was dry beans. -> ave. in soil loss (pg. 18)

0.02-0.64 ↑ erosive

Stanislaus had areas up to 0.43 majority in 0.35 range

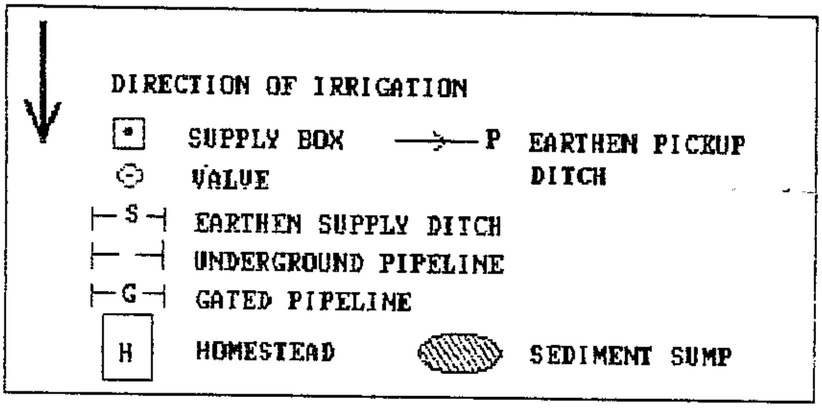
Irrigation water is supplied to the field by irrigation district canals and is applied on the field by siphon pipes and a gated pipeline system. On-field drainage is achieved by the use of earthen pickup ditches. Irrigation-induced tailwater flows into an earthen sediment sump prior to entering Spanish Grant Drainage District drainlines.

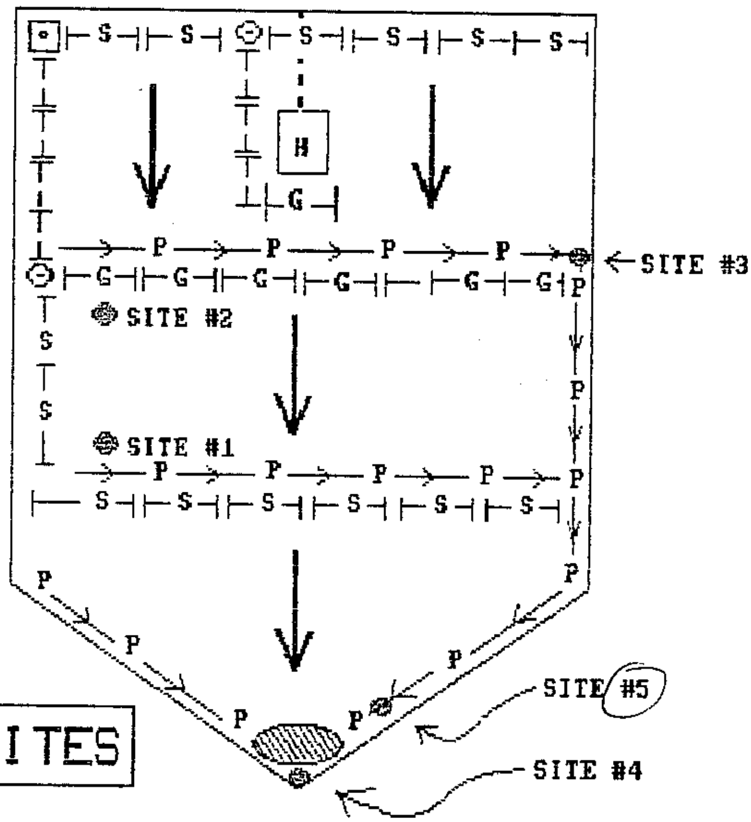
The field is divided into three sections for irrigation purposes. Figure B-2 shows the layout of the field, the direction of irrigation, and identifies sites where flow volume and suspended sediment samples were taken.

APPENDIX B

IRRIGATION AND DRAINAGE LAYOUT FOR ON-FARM EVALUATION

LEGEND:





SAMPLE SITES

SITE #1	ORIFICE PLATES
SITE #2	ORIFICE PLATES
SITE #3	PARSHALL FLUMES 1&2 INCH
SITE #4	STEVENS RECORDER/9 INCH PARSHALL FLUME
SITE #5	SUSPENDED SEDIMENT SAMPLES

? So did the sediment am[...] sump filter [...] of the sediment.

Sample Methods

In order to accurately determine the amount of tailwater leaving the field, it was necessary to install a flow measuring device. A 9" Parshall flume was selected and placed directly upslope of the sediment sump outlet. Irrigation-induced tailwater flows were determined by direct readings over time of the water level on a scale at the flume entrance.

As 60 hours were required to irrigate this 65 acres, it was decided that a flow recording station would be required. A Stevens Recorder was setup for this purpose. Use of the Parshall Flume and an attached stilling well allowed the Stevens Recorder to obtain continuous readings of tailwater flows during the evaluation. Additional measuring devices were also employed. One and two inch flumes, and orifice plates were used to determine stream size applied and tailwater amounts resulting from irrigation of the top and middle sections. Measurements of suspended solids were taken every half hour at the recording station during the first 8 hours of the irrigation. Table B-4 shows tailwater flows and suspended sediment values. Additional samples were taken at sites 1,2,3, and 5 to assess within-field erosion. Samples at sites 3 and 5 were made to determine if a significant amount of the on-field erosion could be a result of the earthen drainage ditch. Flow readings were also taken at sites 1,2, and 3 on a hourly basis during the initial 8 hours.

During the initial 8 hours, furrow flow rates were established and calibration of the Stevens recorder was conducted. During the remaining 52 hours the flow recorder was periodically checked and serviced.

Results

Data compiled from the Stevens Recorder shows that while irrigation induced tailwater flow rates varied greatly, on the average 1.3 cubic feet of tailwater per second (599 gallons per minute) was measured exiting the sump. Figure B-5 depicts the tailwater variation observed at site 4 over the entire 60 hour irrigation.

Several trends are apparent in figure B-5. 1) a regular pattern of increasing and decreasing tailwater flow on 8 and 12 hour cycles. This corresponds with the changing of irrigation sets by the irrigator i.e. the changing of the portion of the field being irrigated. As each set is changed a period of low runoff follows until water applied to the furrow reaches the end of the run and starts contributing tailwater. Tailwater runoff tends to increase as infiltration rates in the furrow decrease until the

APPENDIX B

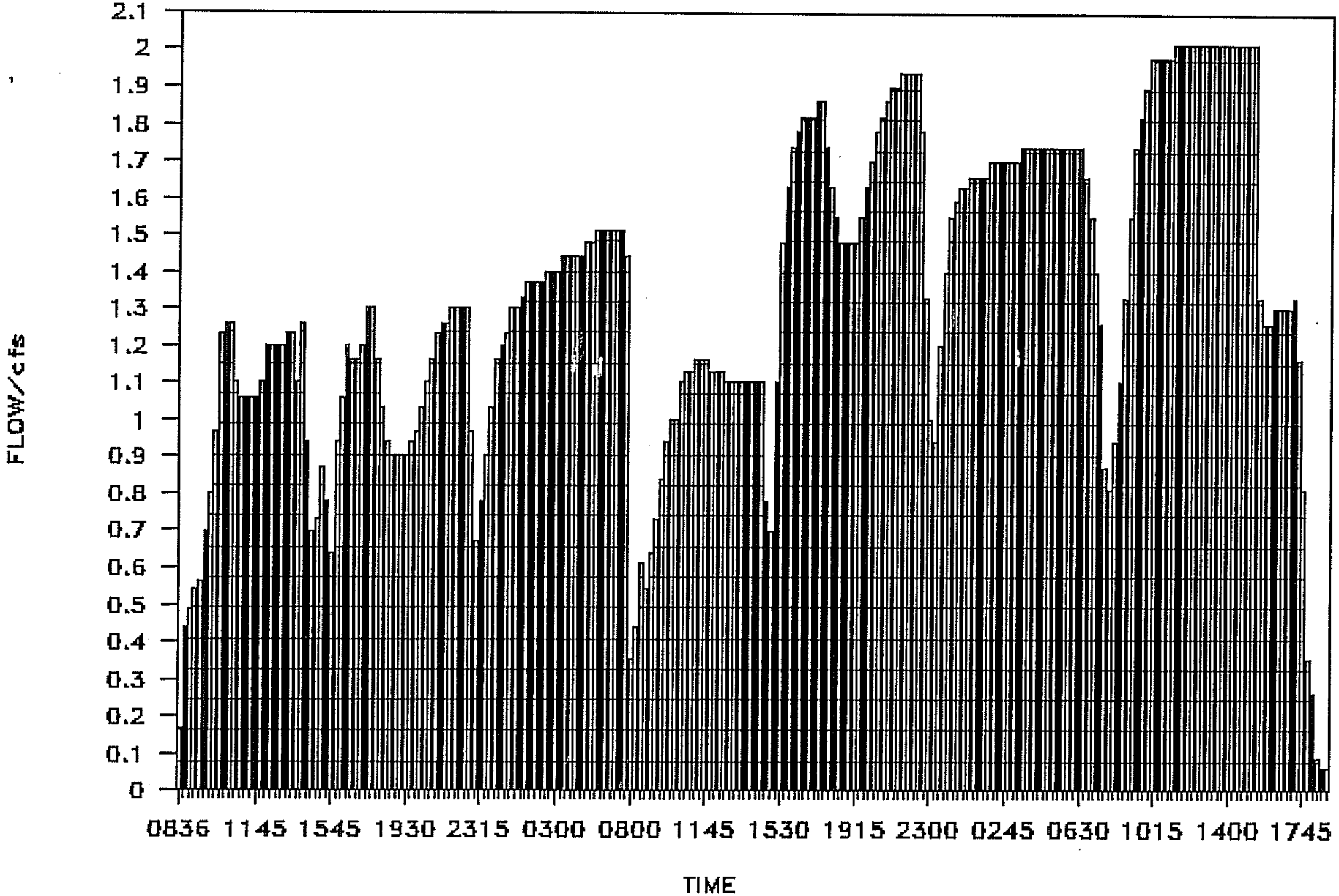
SITE #4 IRRIGATION INDUCED TAILWATER FLOWS AND SUSPENDED SEDIMENT VALUES

SAMPLE #	TIME	FLOW/cfs	SUS SED mg/l	ESTIMATED TONS SED/24HRS
1	0836	.2	1600 mg/l	.7
2	0906	.5	1500 mg/l	2.2
3	0936	.8	2400 mg/l	5.4
4	1006	1.2	2500 mg/l	8.3
5	1030	1.3	2000 mg/l	6.8
6	1100	1.1	1400 mg/l	4.0
7	1130	1.1	1300 mg/l	3.7
8	1200	1.1	1800 mg/l	5.3
9	1230	1.2	1200 mg/l	3.9
10	1300	1.2	1200 mg/l	3.9
11	1333	1.2	1300 mg/l	4.3
12	1400	1.2	1300 mg/l	4.3
13	1430	.9	1100 mg/l	2.8
14	1500	.7	1700 mg/l	3.3
15	1530	.8	1400 mg/l	2.9
16	1600	.9	1600 mg/l	4.0
17	1630	1.2	1200 mg/l	3.9
18	1700	1.2	950 mg/l	3.0

what was the estimate for actual amount that got past sump as well as what would have got past w/out sump?
~10 tons left

APPENDIX B

Flow values for on-farm evaluation



irrigation set is again changed. 2) over the 60 hour irrigation runoff increased. This results from the saturation of the soil in the drain ditches and the more efficient delivery of tailwater to the drain as the irrigation sets moved from the top to the bottom of the field.

Of the 24 acre-feet of water applied, 6.7 acre feet or 28 percent left as tailwater (valued at $5.50/acre foot, the 6.7 acre-feet lost represents a loss of $36.85 or 56 cents per acre). During peak runoff periods during day 3, tailwater discharges reached 42 percent of the water applied

The average concentration of suspended sediment in tailwater during the initial 8 hour period was 1,500 mg/l. When combined with average flow rates for this time period, an erosion rate of at least 4 tons per 24 hours resulted. Extrapolating this data for the remainder of the trial results in a total suspended sediment load of 10 tons for this irrigation on 65 acres of row crop-land.

Readings taken at site 3 show an average suspended sediment level of 3,586 mg/l for the initial 8 hours. These readings indicate that sediment eroded from furrow and earthen drainage channels are significantly higher than tailwater suspended sediment exiting the flow recording station. Deposition of sediment in the sump and adjacent areas of low velocity flow appear account for this difference.

Bean crops in this part of the San Joaquin Valley are typically irrigated five times during the growing season. If the irrigation set times, tailwater levels and suspended sediments measured represent average levels actually achieved during the entire growing season, it is reasonable to expect the export of approximately <u>50 tons of sediment</u> from this field by irrigation runoff. This results in a soil loss rate of .77 tons/ac/yr. Total on-field erosion would predictably be even higher. Double cropping of this ground would result in even higher erosion and sediment loading figures.

APPENDIX C

THE BOARD OF SUPERVISORS
OF THE COUNTY OF STANISLAUS
STATE OF CALIFORNIA

Date: July 23, 1973

In re: Adopting Rules and Regulations for
Designated Storm Drain Maintenance
<u>RESOLUTION</u>
Districts with Respect to Desilting
Drainage Sumps

WHEREAS, Stanislaus County Storm Drain Maintenance Districts numbers 1, 2, 3, 4, 6, 7, 8, 9, and 10 were duly created and formed pursuant to the "Storm Drain Maintenance District Act" (Deering, Water - Uncodified Acts, Act 2208) and pursuant to law this Board is the governing body of each of such districts; and

WHEREAS, this Board, Pursuant to Section 5 of such Act, is authorized to make and enforce rules and regulations and do all things necessary for the proper administration, government and maintenance of such districts; and

WHEREAS, sediment discharged by surface drainage systems in such designated Storm Drain Maintenance Districts may result in waste discharge into canals, the San Joaquin River and other points of discharge in excess of waste discharge requirements of the State Water Quality Board and the Central Valley regional board unless rules and regulations with respect to desilting drainage sumps are made and enforced;

NOW, THEREFORE, BE IT RESOLVED that the following rules and regulations be made and adopted as rules of the above designated Stanislaus County Storm Drain Maintenance Districts:

1. A desilting sump shall be constructed at all inlets to the District drain line. It shall be sized to contain a minimum of 4 cubic yards of storage per acre draining into it.

2. The sump shall be a minimum of 6 feet deep with 2;1 side slopes and a minimum bottom width of 10 feet.

3. The sump shall be located so that the runoff from the field will enter at the opposite end from the drain inlet.

4. The sump shall be cleaned out at least once a year or whenever the sediment level is within 2 feet of the inlet crest.

The following example is for a sump to serve 200 acres, meeting size and design requirements:

Pond Size:	6 ft. depth	40 ft. top width
	2:1 side slopes	116 ft. bottom length
	140 ft. top length	16 ft. bottom width
Capacity of sump:		
	@ 1 ft. level	79 cu. yards
	@ 2 ft. level	178 cu. yards
	@ 3 ft. level	300 cu yards
	@ 4 ft. level	444 cu yards
	@ 5 ft. level	613 cu yards
	@ 5 ft. level	807 cu. yards

A check of turbidity of the outflow shall be made periodically by the Department of Public Works to determine if adequate settling is taking place. If not, the sediment shall be cleaned out by the grower and any needed alteration shall be done to the sump to provide adequate settling. If the grower fails or refuses to do this, after 30 days written notice by the Director of Public Works, the Board of Supervisors may, upon hearing after written notice thereof to the grower, order the inlet closed. Turbidity standards shall be in accordance with the standards of the State Water Control Board as applied at the Vernalis gauging station.

APPENDIX D

NON-POINT SOURCES OF POLLUTION

Pollutant category	Possible sources (alphabetically)
Biological oxygen demand/dissolved oxygen depletion (BOD/DO)	Agriculture (animal & plant waste); Combined sewers: Industries (particularly pulp & paper mills); Municipal wastewater treatment plants; Natural sources
Bacteria (pathogens)	Agriculture (feedlots, manured cropland, pastures, and rangeland); Combined sewers; Municipal wastewater treatment plants; Natural sources
Nutrients	Agriculture; Combined sewers; Constructtion runoff; Municipal wastewater treatment plants; Natural sources; Septic systems; Silviculture
Toxics	Agriculture (pesticides); Combined sewers; Industries; Land disposal of wastes; Municipal wastewater treatment plants; Silviculture; Spills; Urban runoff
Dissolved solids (salinity)	Agriculture; Combined sewers; Mining; Urban runoff
Suspended solids	Agriculture; Combined sewers; Constructtion runoff; Industries; Mining; Silviculture; Urban runoff

(Source: RCA 1987)